NATIONAL COMPETITIVE BIDDING DOCUMENT

FOR

Construction of 132/33KV, 2X50 MVA GIS at Titabor and 132/33KV, 2x50MVA AIS at Chabua along with associated Transmission Lines

(Package (P-II-B))

(Design, Engineering, Manufacture, Assembly, Inspection, Testing at Manufacturer's Works before Dispatch, Packing, Supply, Delivery at Site, Including Insurance During Transit, Subsequent Storage, Erection and Commissioning of GIS, Power Transformers with Associated Switchgears, including Supply & Erection of Substation Steel Structures, Construction of Control Room Building, Erection And Commissioning of new associated Transmission Lines and all other Civil Works on ***Turnkey Basis****)*

SINGLE STAGE TWO ENVELOPE

(e-Tender)

UNDER

ASSAM INTRA-STATE TRANSMISSION SYSTEM ENHANCEMENT PROJECTS

(PHASE II)

funded by

ASIAN INFRASTURCTURE INVESTMENT BANK(AIIB)

VOLUME II: TECHNICAL SPECIFICATION

ASSAM ELECTRICITY GRID CORPORATION LIMITED
The State Transmission Utility of Assam
Regd. Office, Bijulee Bhawan
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TENDER IDENTIFICATION NO.: AEGCL/MD/AIIB/Phase-II/PKG:P-II-B/2023/P-II-B

TABLE OF CONTENTS

CHAPTER 1: STANDARDS & ABBREVIATIONS

1.1 LIST OF SPECIFICATIONS GENERAL STANDARDS AND CODES

India Electricity Rules

Indian Electricity Act

Indian Electricity (Supply) Act

Indian Factories Act

IS-5, -	Colors for Ready Mixed Paints and Enamels.
IS-335, -	New Insulating Oils.
IS-617, -	Aluminium and Aluminium Alloy Ingots and Castings for General Engineering Purposes
IS-1448 (P1 to P 145) -	Methods of Test for Petroleum and its Products.
IS-2071 (P1 to P3) -	Methods of High Voltage Testing.
IS-12063 -	Classification of degrees of protection provided by enclosures of electrical equipment.
IS-2165 P1:1997 - P2:1983	Insulation Coordination.
IS-3043 -	Code of Practice for Earthing
IS-6103 -	Method of Test for Specific Resistance (Resistivity) of Electrical Insulating Liquids
IS-6104 -	Method of Test for Interfacial Tension of Oil against Water by the Ring Method
IS-6262 -	Method of test for Power factor & Dielectric Constant of Electrical Insulating Liquids.
IS-6792 -	Method for determination of electric strength of insulating oils.
IS-5578 -	Guide for marking of insulated conductors.
IS-11353 -	Guide for uniform system of marking & Identification of conductors &apparatus terminals.
IS-8263 -	Methods for Radio Interference Test on High voltage Insulators.
IS-9224(Part1, 2 &4) -	Low Voltage Fuses
IEC-60060(Part1 to P4) -	High Voltage Test Techniques
IEC60068 -	Environmental Test
IEC-60117 -	Graphical Symbols
IEC-60156, -	Method for the Determination of the Electrical Strength of Insulation Oils.
IEC-60270, -	Partial Discharge Measurements.

IEC-60376 -	Specification and Acceptance of New Sulphur Hexafloride
IEC-60437 -	Radio Interference Test on High Voltage Insulators.
IEC-60507 -	Artificial Pollution Tests on High Voltage Insulators to be used on AC Systems.
IEC-60694 -	Common Specification for High Voltage Switchgear & Control gear Standards.
IEC-60815 -	Guide for the Selection of Insulators in respect of Polluted Conditions.
IEC-60865(P1&P2) -	Short Circuit Current - Calculation of effects.
ANSI-C.1/NFPA.70 -	National Electrical Code
ANSI-C37.90A -	Guide for Surge Withstand Capability (SWC) Tests
ANSI- C63.21, -	Specification for Electromagnetic Noise and
C63.3 -	Field Strength Instrumentation 10 KHz to 1
GHZ C36.4ANSI-C68.1 -	Technique for Dielectric Tests
ANSI-C76.1/EEE21 -	Standard General Requirements and Test Procedure for Outdoor Apparatus Bushings.
ANSI-SI-4 -	Specification for Sound Level Metres
ANSI-Y32-2/C337.2 -	Drawing Symbols
ANSI-Z55.11 -	Gray Finishes for Industrial Apparatus and Equipment No.61 Light Gray
NEMA-107T -	Methods of Measurements of RIV of High Voltage Apparatus
NEMA-ICS-II -	General Standards for Industrial Control and Systems
Part I CSI-109	
CISPR-1 -	Specification for CISPR Radio Interference Measuring Apparatus for the frequency range 0.15MHz 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

IS: 10028 (Part2&3) -	Code of practice for selection, installation & maintenance of Transformers (P1:1993), (P2:1991), (P3:1991)
IS-2026(P1toP4) -	Power Transformers
IS-3347(part 1 to Part 8) -	Dimensions for Porcelain transformer Bushings for use in lightly polluted atmospheres.
IS-3639 -	Fittings and Accessories for Power Transformers

IS-6600 -	Guide for Loading of Oil immersed Transformers.
IEC-60076 (Part1to5) -	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 Alternating Current Circuit Breakers
IEC-60427 -	Synthetic Testing of High Voltage alternating current circuit Breakers.
IEC-61264 -	Pressurized Hollow Column Insulators

CURRENT TRANSFORMERS, VOLTAGE TRANSFORMERS AND COUPLING CAPACITOR VOLTAGE TRANSFORMERS

IS-2705-(P1 to P4) -	Current Transformers.
IS: 3156- (P1 to P4) -	Voltage Transformers.
IS-4379 -	Identification of the Contents of Industrial Gas Cylinders
IEC-60044-1 -	Current transformers.
IEC-60044-2 -	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
IS-2099 -	Bushings for Alternating Voltages above 1000V

IEC-60137 -	Insulated Bushings for Alternating Voltages above1000V

SURGE ARRESTERS

IS-3070(PART2) -	Lightning arresters for alternating current systems Metal oxide lightning arrestors without gaps.
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

CUBICLESAND PANELS & OTHER RELATED EQUIPMENTS

IS-722, IS-1248, - IS-3231, 3231 (P-3)	Electrical relays for power system protection
IS: 5039 -	Distributed pillars for Voltages not Exceeding 1000Volts.
IEC-60068.2.2 -	Basic environmental testing procedures
Part2: Test B:	Dry heat
IEC-60529 -	Degree of Protection provided by enclosures.
IEC-60947-4-1 -	Low voltage switchgear and control gear.
IEC-61095 -	Electromechanical Contactors for household and similar purposes.
IEC-60439(P1 & 2) -	Low Voltage Switchgear and control gear assemblies
ANSI-C37.20 -	Switchgear Assemblies, including metal enclosed bus.
ANSI-C37.50 -	Test Procedures for Low Voltage Alternating Current Power Circuit Breakers
ANSI-C39 -	Electric Measuring instrument
ANSI-C83 -	Components for Electric Equipment
IS: 8623: (PartIto3) -	Specification for Switchgear & Control Assemblies.
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-60129 -	Alternating Current Disconnectors (Isolators) and Earthing switches
IEC-1129 -	Alternating Current Earthing Switches Induced Current switching
IEC-60265(Part 1 & 2) -	High Voltage switches
ANSI-C37.32 -	Schedule of preferred Ratings, Manufacturing Specifications and Application Guide for high voltage Air Switches, Bus supports and switch accessories
ANSI-C37.34 -	Test Code for high voltage air switches
NEMA-SG6 -	Power switching equipment

PLCC and line traps

IS-8792 -	Line traps for AC power system.
IS-8793 -	Methods of tests for line traps.
IS-8997 -	Coupling devices for PLC systems.
IS-8998 -	Methods of test for coupling devices for PLC systems
IEC-60353 -	Line traps for A.C. power systems.
IEC-60481 -	Coupling Devices for power line carrier systems.
IEC-60495 -	Single side board powerline carrier terminals
IEC-60683 -	Planning of (single Side-Band) power line carrier systems.
CIGRE -	Teleprotection report by Committee 34
&35. CIGRE -	Guide on power line carrier 1979.
CCIR -	International Radio Consultative Committee
CCITT -	International Telegraph &Telephone Consultative Committee
EIA -	Electric Industries Association

Protection and control equipment

IEC-60051: (P1 to P9) -	Recommendations for Direct Acting indicating analogue electrical measuring instruments and their accessories.
IEC-60255(Part1to23) -	Electrical relays.
IEC-60297 (P1to P4) -	Dimensions of mechanical structures of the 482.6mm (19inches) 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 watthour meters

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

MOTORS

IS-325 -	Three phase induction motors.
IS-4691 -	Degree of protection provided by enclosure for rotating electrical machinery.
IEC-60034(P1 to P19 :) -	Rotating electrical machines
IEC-Document2 -	Three phase induction motors
(Central Office) NEMA-MGI	Motors and Generators

Electronic equipment and components

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

IEC-60068(P1toP5) -	Environmental testing
IEC-60326(P1 to P2) -	Printed boards Material and workmanship standards
IS-1363(P1 to P3) -	Hexagon headbolts, screws and nuts of product grade C.
IS-1364(P1 to P5)	Hexagon head bolts, screws and nuts of products grades A & B.
IS-3138 -	Hexagonal Bolts and Nuts (M42 to M150)
ISO-898 -	Fasteners: Bolts, screws and studs
ASTM -	Specification and tests for materials

Clamps& connectors

IS-5561 -	Electric power connectors.
NEMA-CC1 -	Electric Power connectors for sub station
NEMA-CC3 -	Connectors for Use between aluminum or aluminum-Copper Overhead Conductors

Bus hardware and insulators

IS: 2121 -	Fittings for Aluminum and steel cored Al conductors for overhead power lines.
IS-731 -	Porcelain insulators for overhead power lines with a nominal voltage greater than 1000 V.

IS-2486(P1 to P4) -	Insulator fittings for overhead power lines with a nominal voltage greater than 1000V
IEC-60120 -	Dimensions of Ball and Socket Couplings of string insulator units.
IEC-60137 -	Insulated bushings for alternating voltages above 1000V.
IEC-60168 -	Tests on indoor and outdoor post insulators of ceramic material or glass for Systems with Nominal Voltages Greater than 1000V.
IEC-60233 -	Tests on Hollow Insulators for use in electrical equipment.
IEC-60273 -	Characteristics of indoor and outdoor post insulators for systems with nominal voltages greater than 1000V.
IEC-60305 -	Insulators for overhead lines with nominal voltage above 1000V-ceramic or glass insulator units for ac 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 nominal voltage above 1000V.
IEC-60433 -	Characteristics of string insulator units of the long rod type.
IEC-60471 -	Dimensions of Clevis and tongue couplings of string insulator units.
ANSI-C29 -	Wet process porcelain insulators
ANSI-C29.1 -	Test methods for electrical power insulators
ANSI-C92.2 -	For insulators, wet-process porcelain and toughened glass suspension type
ANSI-C29.8 -	For wet-process porcelain insulators apparatus, post-type
ANSI-G.8 –	Iron and steel hardware
CISPR-7B -	Recommendations of the CISPR, tolerances of form and of Position, Part1
ASTMA-153 -	Zinc Coating (Hot-Dip) on iron and steel Hardware.

Strain and rigid bus-conductor

IS-2678 -	Dimensions & tolerances for Wrought Aluminum and Aluminum Alloys drawn round tube.
IS-5082 -	Wrought Aluminum and Aluminum Alloy Bars. Rods, Tubes and Chapters for Electrical purposes.
ASTM-B 230-82 -	Aluminum 1350 H19 Wire for electrical purposes

ASTM-B231-81 -	Concentric -lay -stranded, aluminium 1350 conductors
ASTM-B221 -	Aluminum -Alloy extruded bar, road, wire, shape
ASTM-B236-83 -	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

IS: 1651 -	Stationary Cells and Batteries, Lead-Acid Type (With Tubular Positive Plates)
IS: 1652 -	Stationary Cells and Batteries, Lead-Acid Type (With Planet Positive Plates)
IS: 1146 -	Rubber and Plastic Containers for Lead-Acid Storage Batteries
IS: 6071 -	Synthetic Separators for Lead-Acid Batteries
IS: 266 -	Specification for Sulphuric Acid
IS: 1069 -	Specification for Water for Storage Batteries
IS: 3116 -	Specification for Sealing Compound for Lead-Acid Batteries
IS: 1248 -	Indicating Instruments
IS: 10918 -	Vented type nickel Cadmium Batteries
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

IS: 3895 -	Mono-crystalline Semiconductor Rectifier Cells and Stacks

IS: 4540 -	Mono-crystalline Semiconductor Rectifier Assemblies and Equipment.
IS: 6619 -	Safety Code for Semiconductor Rectifier Equipment
IS: 2026 -	Power Transformers
IS: 2959 -	AC Contactors for Voltages not Exceeding 1000V
IS: 1248 -	Indicating Instruments
IS: 2208 -	HRC Fuses
IS: 13947(Part-3) -	Airbreak switches, airbreak disconnectors & fuse combination units for voltage not exceeding 1000V AC or 1200V DC
IS: 2147 -	Degree of protection provided by enclosures for low voltage switchgear and control gear.
IS: 6005 -	Code of practice for phosphating of Iron and Steel
IS: 3231 -	Electrical relays for power system protection
IS: 3842 -	Electrical relay for AC Systems
IS: 5 -	Colors for ready mix paint
IEEE-484 -	Recommended Design for installation design and installation of large lead storage batteries for generating station sand 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)
IS-694 -	PVC insulated cables for working voltages up to and including 1100 Volts.
IS-1255 -	Code of practice for installation and maintenance of power cables, up to and including 33 kV rating
IS-1554(P1 and P2) -	PVC insulated (heavy duty) electric cables (part1) For working voltage up to and including 1100 V.
- Part (2)	for working voltage from 3.3 kV up to and including11kV.
IS:1753 -	Aluminium conductor for insulated cables
IS:2982 -	Copper Conductor in insulated cables.
IS-3961(P1 to P5) -	Recommended current ratings for cables.
IS-3975 -	Mild steel wires, formed wires and tapes for armouring of cables.
IS-5831 -	PVC insulating and sheath of electric cables.
IS-6380 -	Elastometric insulating and sheath of electric cables.

IS-7098 -	Cross linked polyethylene insulated PVC sheathed cables for working voltage up to and including 1100 volts.
IS-7098 -	Cross-linked polyethylene insulated PVC sheathed cables for working voltage from 3.3kV up to and including 33kV.
IS-8130 -	Conductors for insulated electrical cables and flexible cords.
IS-1753 -	Aluminum Conductors for insulated cables.
IS-10418 -	Specification for drums for electric cables.
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 upto 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 colors 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 from1kV up to 30 kV
IEC-754(P1 and P2) -	Tests on gases evolved during combustion of electric cables.

Galvanizing

IS-209 -	Zinc Ingot
IS-2629 -	Recommended Practice for Hot-Dip galvanizing on iron and steel.
IS-2633 -	Methods for testing uniformity of coating of zinc coated articles.
ASTM-A-123 -	Specification for zinc (Hot Galvanizing) Coatings, on products Fabricated from rolled, pressed and forged steel shapes, plates, bars and strips.
ASTM-A-121-77 -	Zinc-coated (Galvanized) steel barbed wire

Painting

IS-6005 -	Code of practice for phosphating of iron and steel.
ANSI-Z551 -	Gray finishes for industrial apparatus and Equipment

SSPEC - Steel structure painting council

Fire protection system

Fire protection manual issued by tariff advisory committee (TAC), NFPA and National Building code 2016 of India

HORIZONTAL CENTRIFUGAL PUMPS

IS: 6595(Part2) - Horizontal centrifugal pumps for clear, cold water

IS: 9137 - Code for acceptance test for centrifugal & axial pumps

IS: 5120 - Technical requirement- Rotodynamic special purpose pumps

API-610 - Centrifugal pumps for general services - Hydraulic Institutes Standards

BS: 599 - Methods of testing pumps

PTC-8.2 - Power Test Codes-Centrifugal pumps\

DIESEL ENGINES

IS: 10000 - Methods of tests for internal combustion engines

IS: 10002 - Specification for performance requirements for constant speed compression ignition engines for general purposes (above 20 kW)

BS: 5514 - The performance of reciprocating compression ignition (Diesel) engines, utilizing liquid fuel only, for general purposes

ISO: 3046 - Reciprocating internal combustion engines performance

IS: 554 - Dimensions for pipe threads where pressure tight joints are required on threads

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

PIPINGVALVES & SPECIALITIES

IS: 636 - Non percolating flexible fire fighting delivery hose

IS: 638 - Sheet rubber jointing and rubber inserting jointing

IS: 778 - Gun metal gate, globe and check valves for general purpose

IS: 780 - Sluice valves for water works purposes (50 to300 mm)

IS: 901 - Couplings, double male and double female instantaneous pattern for fire fighting

IS: 902 - Suction hose couplings for firefighting purposes

IS: 903 - Fire hose delivery couplings branch pipe nozzles and nozzle spanner

IS: 1538 - Cast iron fittings for pressure pipes for water, gas and sewage

IS: 1903 - Ball valve (horizontal plunger type) including floats for water supply purposes

IS: 2062 -	SP for weldable structural steel
IS: 2379 -	Color Code for the identification of pipelines
IS: 2643 -	Dimensions of pipe threads for fastening purposes
IS: 2685 -	Code of Practice for selection, installation and Maintenance of sluice valves
IS: 2906 -	Sluice valves for water-works purposes (350 to 1200mm size)
IS: 3582 -	Basket strainers for firefighting purposes (Cylindrical type)
IS: 3589 -	Electrically welded steel pipes for water, gas and sewage (150 to2000 mm nominal diameter)
IS: 4038 -	Foot valves for water works purposes
IS: 4927 -	Unlined flax canvas hose for fire fighting
IS: 5290 -	Landing valves (internal hydrant)
IS: 5312 -	Swing check type reflex (non-return) valves (Part-I)
IS: 5306 -	Code of practice for fire extinguishing installations and equipment on premises
Part-I -	Hydrant systems, hose reels and foam inlets
Part-II -	Sprinkler systems
BS: 5150 -	Specification for cast iron gate valves

MOTORS & ANNUNCIATION PANELS

IS: 325 -	Three phase induction motors
IS: 900 -	Code of practice for installation and maintenance of induction motors
IS: 996 -	Single phase small AC and universal electric motors
IS: 1231 -	Dimensions of three phase foot mounted induction motors
IS: 2148 -	Flame proof enclosure of electrical apparatus
IS: 2223 -	Dimensions of flange mounted AC induction motors
IS: 2253 -	Designations for types of construction and mounting arrangements of rotating electrical machines
IS: 2254 -	Dimensions of vertical shaft motors for pumps
IS: 3202 -	Code of practice for climate proofing of electrical equipment
IS: 4029 -	Guide for testing three phase induction motors
IS: 4691 -	Degree of protection provided by enclosure for rotating electrical machinery
IS: 4722 -	Rotating electrical machines
IS: 4729 -	Measurement and evaluation of vibration of rotating electrical machines

IS: 5572 -	Classification of hazardous areas for electrical (Part-I) installations (Areas having gases and vapours)
IS: 6362 -	Designation of methods of cooling for rotating electrical machines
IS: 6381 -	Construction and testing of electrical apparatus with type of protection 'e'
IS: 7816 -	Guide for testing insulation for rotating machine
IS: 4064 -	Air break switches
IECDOCUMENT 2 -	Three Phase Induction Motor (Control Office) 432
VDE0530 Part I / 66 -	Three Phase Induction Motor
IS: 9224 - (Part-II)	HRC Fuses
IS: 6875 -	Push Button and Control Switches
IS: 694 -	PVC Insulated cables
IS: 1248 -	Indicating instruments
IS: 375 -	Auxiliary wiring & busbar markings
IS: 2147 -	Degree of protection
IS: 5 -	Color Relay and timers
IS: 2959 -	Contactors

PG Test Procedures

NFPA-13 -	Standard for the installation of sprinkler system
NFPA-15 -	Standard for water spray fixed system for the fire protection
NFPA-12A -	Standard for Halon 1301 Fire Extinguishing System
NFPA-72E -	Standard on Automatic Fire Detectors

Fire Protection Manual by TAC (Latest Edition)

NFPA-12 -	Standard on Carbon dioxide extinguisher systems
IS: 3034 -	Fire of industrial building: Electrical generating and Distributing stations code of practice
IS: 2878 -	CO2 (Carbon dioxide) Type Extinguisher
IS: 2171 -	DC (Dry Chemical Powder) type
IS: 940 -	Pressurized Water Type

D.G.SET

IS: 10002 -	Specification for performance requirements for constant speed compression ignition (diesel engine) for general purposes
IS: 10000 -	Method of tests for internal combustion engines
IS: 4722 -	Rotating electrical machines-specification
IS: 12063 -	Degree of protection provided by enclosures

IS: 12065 - Permissible limit of noise levels for rotating electrical machines.

- Indian Explosive Act1932

Steel structures for Substation.

IS-228(1992) -	Method of Chemical Analysis of pig iron, cast iron and plain carbon and low alloy steels.
IS-802(2015/P1 to 3) -	Code of practice for use of structural steel in overhead transmission line towers.
IS-806 -	Code of practice for ruse of steel tubes in general building construction
IS-808 -	Dimensions for hot rolled steel beam, column channel and angle chapters.
IS-814 -	Covered electrodes for manual arc welding of carbon of carbon manganese steel.
IS-816 -	Code of Practice for use of metal arc welding for general construction in Mild steel
IS-817 -	Code of practice for training and testing of metal arc welders.
Part 1:	Manual Metal arc welding.
IS-875(P1 to P4) -	Code of practice for design loads (other than earthquake) for buildings and structures.
IS-1161 -	Steel tubes for structural purposes.
IS-1182 -	Recommended practice for radiographic examination of fusion welded butt joints in steel plates.
IS-1363(P1 to P3) -	Hexagonal head bolts, screws &nuts of products grade C.
IS-1364 -	Hexagon headbolts, screws and nuts of product grades A and B.
IS-1367 (P1 to P18) -	Technical supply condition for threaded steel fasteners.
IS-1599 -	Methods for bend test.
IS-1608 -	Method for tensile testing of steel products.
IS-1893 -	Criteria for earthquake resistant design of Structures
IS-1978 -	Line Pipe.
IS-2062 -	Steel for general structural purposes.
IS-2595 -	Code of practice for Radiographic testing.
IS-3063 -	Single coil rectangular section spring washers for bolts, nuts and screws.
IS-3664 -	Code of practice for ultrasonic pulse echo testing by contact and immersion methods.

IS-7205 -	Safety code for erection of structural steel work.
IS-9595 -	Recommendations for metal arc welding of Carbon and carbon manganese steels.
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 embalmment of Hot Galvanized structural steel products and procedure for detaching embroilments
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
AWSD1-0 -	Code for welding in building construction welding inspection
AWSD1-1 -	Structural welding code
AISC -	American institute of steel construction
NEMA-CG1 -	Manufactured graphite electrodes

Piping and pressure vessels

IS-1239(Part 1 and 2) -	Mild steel tubes, tubulars and other wrought steel fittings
IS-3589 -	Seamless electrically welded steel pipes for water, gas and sewage.
IS-6392 -	Steel pipe flanges
ASME -	Boiler and pressure vessel code
ASTM-A120 -	Specification for pipe steel, black and hot dipped, zinc-coated (Galvanized) welded and seamless steel pipe for ordinary use
ASTM-A53 -	Specification for pipe, steel, black, and hot- dipped, zinc coated welded and seamless
ASTM-A106 -	Seamless carbon steel pipe for high temperature service

ASTM-A284 -	Low and intermediate tensile strength carbon- silicon steel plates for machine parts and general construction.
ASTM-A234 -	Pipe fittings of wrought carbon steel and alloy steel for moderate and elevated temperatures
ASTM-S181 -	Specification for forgings, carbon steel for general purpose piping
ASTM-A105 -	Forgings, carbon steel for piping components
ASTM-A307 -	Carbon steel externally treated standard fasteners
ASTM-A193 -	Alloy steel and stainless steel bolting materials for high temperature service
ASTM-A345 -	Flat rolled electrical steel for magnetic applications
ASTM-A197 -	Cupola malleable iron
ANSI-B2.1 -	Pipe threads (Except dry seal)
ANSI-B16.1 -	Cast iron pipe flanges and glanged fitting.
Class 25,125, 250 and 800	
ANSI-B16.1 -	Malleable iron threaded fittings, class 150 and 300
ANSI-B16.5 -	Pipe flanges and flanged fittings, steel nickel alloy and other special alloys
ANSI-B16.9 -	Factory-made wrought steel butt welding

Fittings

ANSI-B16.11 -	Forged steel fittings, socket-welding and threaded
ANSI-B16.14 -	Ferrous pipe plug, bushings and locknuts with piple threads
ANSI-B16.25 -	Butt welding ends
ANSI-B18.1.1 -	Fire hose couplings screw thread.
ANSI-B18.2.1 -	Inch series square and hexagonal bolts and screws
ANSI-B18.2.2 -	Square and hexagonal nuts
NSI-B18.21.1 -	Lock washers
ANSI-B18.21.2 -	Plain washers
ANSI-B31.1 -	Power piping
ANSI-B36.10 -	Welded and seamless wrought steel pipe
ANSI-B36.9 -	Stainless steel pipe

ACSR MOOSE CONDUCTOR

IS:6745	Methods for Determination of
BS:443-1969	Mass of zinc coating on zinc
IS:8263	Coated Iron and Steel Articles

Methods for Radio Interference

IEC: 437-1973	Test on High Voltage Insulators

NEMA: 107-1964 CISPR	
IS: 209	Zinc Ingots BS: 3436-1961
IS: 398	Aluminum Conductors for Overhead Transmission Purposes
IEC: 209-1966	
Part-V	
BS: 215(Part-II)	Aluminum Conductors galvanized
IEC: 209-1966	Steel reinforced extra high Voltage (400 kV and above)
IS: 1778	Reels and Drums for
BS: 1559-1949	Bare Conductors
IS: 1521	Method for Tensile Testing ISO/R89-1959of steel wire
IS: 2629	Recommended practice for Hot dip Galvanizing on Iron and Steel.
IS: 2633	Method for Testing Uniformity of coating of zinc Coated
Articles.	
IS: 4826	Hot dip galvanised coatings On round steel wires
ASTMA-472- 729	

GALVANISED STEEL EARTHWIRE

IS: 1521	Method for Tensile Testing
ISO/R:89-1959	of Steel Wire
IS: 1778	Reels and Drums for Bare Conductors
IS: 2629	Recommended practice for Hot Dip Galvanizing on Iron and Steel.
IS: 2633	Methods for testing Uniformity of Coating of Zinc Coated Articles.
IS: 4826	Hot dip Galvanised Coatings ASTM:A 475-72aon Round Steel Wires
BS: 443-1969	
IS: 6745	Method for Determination BS: 443-1969 of mass of Zinc Coating on Zinc coated Iron and Steel Articles.
IS: 209	Zinc ingot BS: 3463-1961
IS: 398(Pt. I to	Aluminum Conductors for
BS: 215 (Part-II) P5:1992)	overhead transmission purposes.

Lighting Fixtures and Accessories

IS: 16103 (All parts)	**LED module for General Lightning**
IS: 1913	General and safety requirements for electric lighting fittings.
IS: 3528	Waterproof electric lighting fittings.

IS: 4012	Dust proof electric lighting fittings.
IS: 4013	Dust tight proof electric lighting fittings.
IS: 10322	Industrial lighting fittings with metal reflectors.
IS: 10322	Industrial lighting fittings with plastic reflectors.
IS: 2206	Well glass lighting fittings for use underground in mines (non-flameproof type).
IS: 10322	Specification for flood light.
IS: 10322	Specification for decorative lighting outfits.
IS: 10322	Luminaries for street lighting
IS: 2418	Tubular fluorescent lamps
IS: 9900	High pressure mercury vapour lamps.
IS: 1258	Specification for Bayonet lamp fluorescent lamp.
IS: 3323	Bi-pin lamp holder tubular fluorescent lamps.
IS: 1534	Ballasts for use in fluorescent lighting fittings. (Part-I)
IS: 1569	Capacitors for use in fluorescent lighting fittings.
IS: 2215	Starters for fluorescent lamps.
IS: 3324	Holders for starters for tubular fluorescent lamps
IS: 418	GLS lamps
IS: 3553	Water tight electric fittings
IS: 2713	Tubular steel poles
IS: 280	MS wire for general engg. Purposes

Conduits, Accessories and Junction Boxes

IS: 9537	Rigid steel conduits for electrical wiring
IS: 3480	Flexible steel conduits for electrical wiring
IS: 2667	Fittings for rigid steel conduits for electrical wiring
IS: 3837	Accessories for rigid steel conduits for electrical wiring
IS: 4649	Adaptors for flexible steel conduits.
IS: 5133	Steel and Cast Iron Boxes
IS: 2629	Hot dip galvanizing of Iron &Steel.

Lighting Panels

IS: 13947	LV Switchgear and Control gear (Part 1 to 5)
IS: 8828	Circuit breakers for over current protection for house hold and similar installations.
IS: 5	Ready mix paints
IS: 2551	Danger notice plates
IS: 2705	Current transformers
IS: 9224	HRC Cartridge fuse links for voltage above 650V (Part-2)

IS: 5082	Wrought aluminium and Al. alloys, bars, rods, tubes and sections for electrical purposes.
IS: 8623	Factory built Assemblies of Switchgear and Control Gear for voltages upto and including 1000VAC and1200VDC.
IS: 1248	Direct Acting electrical indicating instruments

Electrical Installation

IS: 1293 3	Pin plug
IS: 371	Two to three ceiling roses
IS: 3854	Switches for domestic and similar purposes
IS: 5216	Guide for safety procedures and practices in electrical work.
IS: 732	Code of practice for electrical wiring installation (system voltage not exceeding 650Volts.)
IS: 3043	Code of practice for earthing.
IS: 3646	Code of practice of interior illumination part II &III.
IS: 1944	Code of practice for lighting of public through fares.
IS: 5571	Guide for selection of electrical equipment for hazardous areas.
IS: 800	Code of practice for use of structural steel in general building construction.
IS: 2633	Methods of Testing uniformity of coating on zinc coated articles.
IS: 6005	Code of practice for phosphating iron and steel.

INDIAN ELECTRICITY ACT

INDIAN ELECTRICITY RULES

LT SWITCHGEAR

IS: 8623(Part-I)	Specification for low voltage switchgear and control gear assemblies
IS: 13947(Part-I)	Specification for low voltage switchgear and control gear,
Part 1	General Rules
Part 2	circuit breakers.
Part3	Switches, Disconnectors, and fuse combination units
Part4	Contactors and motors starters.
Part5	Control-circuit devices and switching elements
Part6	Multiple function switching devices.
Part7	Ancillary equipment
IS: 12063	Degree of protection provided by enclosures
IS: 2705	Current Transformers

IS: 3156	Voltage Transformers
IS: 3231	Electrical relays for power system protection
IS: 1248	Electrical indicating instruments
IS: 722 AC	Electricity meters
IS: 5578	Guide for marking of insulated conductors of apparatus terminals
IS: 13703(part1)	Low voltage fuses for voltage not exceeding 1000V AC or 1500VDC
Part1	General Requirements
Part 2	Fuses for use of authorized persons
IS: 6005	Code of practice of phosphating iron and steel
IS: 5082	Wrought Aluminum and Aluminum alloys for electrical purposes
IS: 2633	Hot dip galvanizing.

All Equipments/Materials/Accessories shall comply with these standards

CHAPTER 2: INFORMATION TO BIDDERS (ITB)

2.1 Project Location & Project Co-ordinates:

The project sites are located at the following locations

i. Chabua, Distirct: Dibrugarh having GPS coordinates 27°27'56.34"N 95°11'27.57"E.
ii. Titabor, Distirct: Jorhat having GPS coordinates 26°36'58.79"N 94°15'02.20"E.

TERMINOLOGY USED IN TECHNICAL SPECIFICATIONS:

1) AEGCL, Purchaser, Owner etc., shall mean AEGCL or authorized person by AEGCL.
2) Bidder, Supplier, Vendor, Manufacturer shall mean EPC Contractor or represented by him.

2.2 Project Site information:

The relevant site information relating to these projects and information that would be required to implement these projects can be obtained in the "**Volume III – BID PURPOSE DRAWINGS, SCHEDULE OF QUANTITIES AND MISCELLANEOUS DOCUMENTS"**. Bidders can use this information as a basic guide and verify the site condition physically by visiting the site before bidding.

2.3 Climatic condition:

Location	Chabua and Titabor
Outdoor temperature	35° C
Minimum outdoor temperature	40° C
Maximum Oil Temperature	60° C
Maximum relative Humidity	86%
Minimum relative Humidity	65%
Average no of thunderstorm Days per annum	70
Average no of rainy days Per annum	150
No of months of tropical Monsoon conditions	4
Design Ambient Temperature	50° Centigrade
Minimum temperature	0° Centigrade
Wind Zone	Zone 5
Average annual rainfall	3200 mm
Wind Pressure	793 N/m2
Altitude not exceeding	1000M
Seismic Data	IS:802 Part1/Sec 1-2015, ZONE-V

2.4 Equipment Selection Criteria:

The equipment to be offered under the specifications shall be of current & proven design by way of commercial operation for a minimum period of three (3) years. Bidders shall furnish documentary evidence of satisfactory commercial operation / performance of equipment from a minimum of two actual users in the form of authenticated certificate and reference list of Users.

2.5 Approved Manufacturers:

All the equipment and items offered shall be of any one of the approved makes**:** The equipment shall generally be for use in moderately hot and humid tropical climate conducive to rust and fungus growth unless otherwise specified.

2.6 Scope of supply & Works:

2.6.1 Design, Engineering, Manufacture, FAT, Supply and delivery of equipment as specified in this document like GIS, Power Transformers, Transmission line towers, Cables (HT & LT including termination kits), Control and relay panels, SAS panels, Auxillary Transformers, LT panels, Substation structures, buildings and all other associated equipment/ material as per this tender specification and Bill of quantities.

2.6.2 Design, Engineering, Manufacture, Supply and delivery of structure and associated materials for housing / mounting transformers, all related civil works for substation and transmission lines, etc as per this tender specification and Bill of quantities.

2.6.3 Survey, Erection, testing at site (SAT), Includes installation of HT cables between the Transformers and 33kV panels, switchgears, commissioning of GIS with all related civil works and earthing works as per this tender specification and Bill of quantities. Installation of structures / foundations for mounting of transformer with all necessary civil works. The works include all charges and expenses associated with securing necessary approvals / sanctions from local regulatory authorities viz. forest, municipalty, PTCC, NHAI/ SH, Avaiation, Railways etc. and all other related civil administration.

Necessary survey including check and detail survey for Transmission lines. Design of tower foundation, stringing etc.

2.6.4 Erection and commissioning of common structures for housing / Installation all equipments with related civil works and earthing as per this tender specification and Bill of quantities.

2.6.5 Dismantling of the existing structures of Existing erected distribution/transmission system and transportation of these materials to designated location as provived by the employer . Includes necessary labour, loading, unloading works and hiring of machinery (such as cranes etc.).

2.6.6 All issues arising out of any damage to the Employer/ Engineer materials , equipment’s like transformer, GIS, Cables etc. and assets on execution of the contractcovered under the scope of the contractor.

2.6.7 All transportation of materials that is covered in the scope of works shall be ensured to be transported without damage to these materials; the liability in this context is with the contractor. Temporary power supply if required, for field works is in the scope of the bidder.

2.6.8 The contract shall also encompass all necessary project management with quality control, data engineering, acceptance testing, training, documentation and Guarantees.

Safety of contractor personnel and the public at the designated site locations, also involved work spots is responsibility of the contractor.

2.6.9 Obtaining of Right of Way (ROW) as per Clause 2.7 (chapter 2) of this document (Volume II).

2.6.10: All equipments and works shall be executed on Turnkey basis.

2.6.11 The present scope of Design, supply, erection and commissioning work and space for future expansion for construction of 132/33kV GIS and 132/33kV AIS , with transformation ratio of 132/33kV , 2x50 MVA; at Titabor and Chabua with Bay Augmentation and associated Transmission Lines are briefly detailed as below:

132/33kV Titabor GSS

Transformer & Reactors

Transformer: 2X50 MVA, 3-ph,132/33kV

Station transformers: 2x 250 kVA, 33/0.4kV

132/33kV Chabua GSS

Transformer & Reactors

Transformer: 2X50 MVA, 3-ph,132/33kV

Station transformers: 2x 250 kVA, 33/0.4kV

132kV GIS Bays at Titabor :

ICT bays: 2 nos.

Line bays: 2 nos. (for 132kV Titabor-Mariani D/C Transmission Line).

Bus coupler bay: 1 Nos

Future bays: 6 line bays, 1 ICT bays

132kV AIS Bays at Chabua:

ICT bays: 2 nos.

Line bays: 2 nos. (for 132kV Tinsukia – Dibrugarh Transmission Line LILO).

Bus coupler bay: 1 Nos

Future bays: 6-line bays, 1 ICT bay

33kV AIS Bays at Titabor :

ICT bays: 2 nos.

Line bays: 6 nos.

Bus Sectionalizer: 1 Nos

Station Transformer bays: 2nos.

PT Bays: 2 Nos

Future bays: 4 line bays, 1 ICT bays, 1 PT Bays, 1 Bus Sectionalizer.

33kV AIS Bays at Chabua:

ICT bays: 2 nos.

Line bays: 7 nos.

Bus Sectionalizer: 1 Nos

Station Transformer bays: 2nos.

PT Bays: 2 Nos

Future bays: 4-line bays, 1 ICT bays, 1 PT Bays, 1 Bus Sectionalizer.

<u>Remote End Bay Equipments at 220/132/33kV Tinsukia GSS</u>

<u>132kV Chabua Bay at Tinsukia end:</u>

Replacement of 132kV Isolators, Circuit Breaker and CT along with reconductoring of bay from busbar to outgoing gantry with HTLS (ACCC Casablanca) conductor.

<u>Remote End Bays at 220/132/33kV Mariani GSS</u>

<u>132kV AIS Bays :</u>

Line bays: 2 nos. (for 132kV Titabor-Mariani D/C Transmission Line) with Cable Link as described below and as per layout.

The entire work of de stringing of conductors, dismantling of existing Equipment Structures and foundation (if required), including all the works like land fill, PCC Gravelling, earthing works etc. (as required) and other Civil and Electrical Works for completion of the 132kV Bays shall be under the scope of the Successful Bidder.

Associated Transmission Lines at Titabor

1. 132kV Mariani-Titabor D/C Transmission Line with OPGW Link.
2. At Mariani GSS End, the Connection between the 132kV Line Bays (existing Switchyard) and the Outgoing Bays (new extended switchyard) shall be through 1000sqmm XLPE Cable to be laid in Cable Trench as per the Layout.
3. Design and fabrication of new 132kV D/C Tower as per IS 2015 for the entire line.
4. The HF Coxial Cable for PLCC Link Establishment and the Approach Cable for OPGW Link Establishment will run through the same trench and branches to the Panel Room
5. The connection from dead end tower to the line gantry shall be under the scope of the successful bidder at both ends.

Associated Transmission Lines at Chabua

1. Establishment of 132kV LILO at Chabua GSS from existing 132kV Tinsukia-Dibrugarh (existing) single circuit line using HTLS (ACCC Casablanca) conductor.
2. Re-stringing of Tinsukia-Chabua portion of 132kV Tinsukia-Dibrugarh (existing) single circuit line with HTLS (ACCC Casablanca) conductor.
3. Design and fabrication of new 132kV D/C Tower as per IS 2015 for the LILO section.
4. Restringing of 96F OPGW for the link between Dibrugarh GSS – Chabua GSS and Chabua GSS – Tinsukia GSS including patching of fibres till FODP at all the 3 locations.

Establishment of new 132/33 kV GIS at Titabor

Design, engineering, manufacture, testing at manufacturer's works, supply including transportation and insurance, unloading, storage, erection, testing and commissioning at site for the following equipment/items, complete in all respects:

145kV Gas Insulated Switchgear

145kV GIS

Two Set of 3-Phase Encapsulated, 3150A, 40kA for 3 second, SF6 gas- insulated metal enclosed bus bar of 145kV, each set comprising of the following:-

Bus bars enclosures running across the length of the switchgear to interconnect each of the circuit breaker bay modules in **Double Bus bar** system.

3-phase, 3150A, group operated isolator switches, complete with manual and motor driven operating mechanisms.

3-phase, single pole group operated safety grounding switches, complete with manual and motor driven operating mechanisms.

Three (3) numbers 1-phase Potential Transformers with Isolating Link

3-phase, single pole group operated safety grounding switches, complete with manual and motor driven operating mechanisms separately for bus earthing.

Gas monitoring devices, barriers, pressure switches, UHF PD Sensors, support structure etc. as required.

Local control cubicle (Standalone)

Extension Module:

End Piece (Interface) module with the test link for Future extension (on both side) of Bus bar module with all related accessories shall be provided. The end piece module may be designed in such a way so that future GIS module may be tested without extending voltage to existing bus by removing the test link. End interface modules for both the buses shall be in one alignment.

145kV, 40kA for 3 second, SF6 gas-insulated metal enclosed ICT bay module each set comprising of the following:-

One (1) number 3-phase, 3150A, SF6 insulated circuit breaker complete with operating mechanism.

Three (3) numbers 1-phase, 600-300/1A, (0.2S-PX-PX-PX-PX-PX), 6-core, multi ratio, current transformers duly distributed on both side of circuit breaker. (HV side of 50 MVA)

3-phase, 3150A, single pole group operated disconnector switches, complete with manual and motor driven operating mechanisms.

3-phase, single pole group operated safety grounding switches, complete with manual and motor driven operating mechanisms.

3-phase (isolated) SF6 ducts inside GIS hall (upto the outer edge of the wall of GIS Hall)

Gas monitoring devices, barriers, pressure switches UHF PD Sensors, support structure etc. as required.

Local Control Cubicle (Standalone)

145kV, 40kA for 3 second, SF6 gas-insulated metal enclosed Line bay module each set comprising of the following:-

One (1) number 3-phase, 3150A, SF6 insulated circuit breaker complete with operating mechanism.

Three (3) numbers 1-phase, 1200-800-400/1A (0.2S-PX-PX-PX-PX-PX), 6-core, multi ratio, current transformers duly distributed on both side of circuit breaker.

3-phase, 3150A, group operated disconnector switches, complete with manual and motor driven operating mechanisms.

3-phase, group operated safety grounding switches, complete with manual and motor driven operating mechanisms.

3-phase, high speed fault make grounding switch, complete with group operated manual and motor driven operating mechanisms.

3-phase (isolated) SF6 ducts inside GIS hall (upto the outer edge of the wall of GIS Hall)

Gas monitoring devices, barriers, pressure switches UHF PD Sensors, support structure etc. as required.

Local Control Cubicle. (Standalone)

145kV, 40kA for 3 second, SF6 gas-insulated metal enclosed Bus Coupler bay module each set comprising of the following:-

One (1) number 3-phase, 3150A, SF6 insulated circuit breaker complete with operating mechanism.

Three (3) numbers 1-phase, 3000-1600-800/1-1-1-1-1-1A, (0.2S-PX-PX-PX-PX-PX), 6-core, multi ratio, current transformers duly distributed on both side of circuit breaker.

3-phase, single pole 3150A, group operated isolator switches, complete with manual and motor driven operating mechanisms.

3-phase, single pole group operated safety grounding switches, complete with manual and motor driven operating mechanisms.

Gas monitoring devices, barriers, pressure switches UHF PD Sensors, support structure etc. as required.

Local Control Cubicle (Stand alone)

145kV Gas Insulated Bus Ducts(GIB):-

For making connections with outdoor Auto Transformers & overhead lines, 145kV Three phase encapsulated Gas Insulated Bus Duct (Including support structure, gas monitoring device, gas barrier, UHF PD Sensor etc.) shall be required and the same shall be paid as per unit rate quoted in Bid Price Schedule. This outdoor bus duct shall be measured from outer edge of the wall. SF6 gas duct inside GIS building are part of respective GIS Module.

The GIB duct length shall be optimized further without affecting the switchyard arrangement and bay orientation and also any of the functional requirements specified.

145kV Gas Insulated SF6 to Air Termination:-

145kV, 3150A, 3-phase SF6/ air bushings along with terminal connectors & support structure for outdoor connections to connect GIS with 132kV side of 132/33kV Power - Transformer and overhead lines.

Testing and Maintenance Equipment as per **BPS** (Bid Price Schedule).

Mandatory Spares as per **BPS** (Bid Price Schedule).

Any other equipment/material required to complete the specified GIS scope of work shall be quoted in the relevant line item of the BPS.

132kV GIS Building size shall be such that, all the present and future modules can be installed with additional space for two numbers of extension modules and three numbers of maintenance bays with additional free space. Relay room shall accommodate all the present and future control and protection panels along with PLCC, FOTE and FDA panels. Ladders shall be provided for movement of personnel to the top of the relay room and also to the top of the GIS building for any maintenance related work.

SAS room in the control room building shall preferably be in the first floor and shall be in such a position so that all the three switchyards i.e. 132 and 33kV along with the transformers are visible from the SAS room. SAS panels, Gateway Panels, Aux BCU panels etc. shall be housed in the SAS room. A proper and robust lifting arrangement (hydraulic/chain pulley) shall be provided for easy lifting of the SAS panels from the ground level to the first floor.

<u>33kV Section</u>

33kV Bus shall be 3 Inch IPS Aluminum Tube with Necessary Support structures as per detail engineering. The 33kV Outgoing Bays shall be as per the drawings and BPS.

<u>Air insulated switchgear (AIS) and Other Main Equipment</u>

Integration of IEC61850 communication based monitoring equipment’s like On-line Insulating Oil drying system, Digital RTCC relays, etc. {as applicable for 220/132 kV, 3-Phase Autotransformer, with substation automation system is also included under present scope

Further the contractor shall also supply necessary BCUs for control and monitoring of substation auxiliary system. SAS server & gateway shall have licenses sufficient for all, 220kV, 132kV bays (i.e. present scope bays and all future scope bays as applicable) at Titabor S/S.

<u>Bay Extension Works at 220/132/33kV Mariani GSS</u>

<u>132kV Line Bays:</u>

The 132kV Line Bays shall be constructed as per the Layout in both the Existing Switchyard and New Switchyard Extension. The connection between the new extended bay portion and the bay in the existing switchyard shall be through 132kV 1000sqmm XLPE Cu Cable (1 run per phase+1 run spare cable for each bay) to be laid in the Cable Trench as per layout. Minimum Bending Radius of 25D shall be maintained for the 132kV XLPE Cable.

For establishment of the PLCC and OPGW link, the HF Coaxial Cable and the Approach Cable (96F) will run along the Cable trench (in separate Trays) and branches to the panel room.

For the Line Differential Relay's communication, the pairs of Optical Fiber of the 96F OPGW and approach cable shall be used.

During the Construction of the 132kV Bays at Mariani GSS, the entire work of de stringing of conductors, dismantling of existing Equipment Structures and foundation (if required), dismantling of existing transformer pad and foundation, dismantling of existing Store, Dragging of Transformer, rerouting of existing Switchyard Peripheral Road, Construction of new peripheral road, including all the works of new Switchyard Extension like land fill, PCC Gravelling, Earthing works etc and other Civil and Electrical Works for completion of 132kV Bays for evacuation of power to Titabor GSS shall be under the scope of the Successful Bidder.

Integration of Line Bays under present scope with existing Sub Station Automation System for MHMI and RHMI:

The scope of the Bidder shall include but not limited to integration of IEDs under present scope of construction with the existing substation automation as per tender drawings and documents, which is based on IEC 61850 and capability enhancement of same as required including up-dating of system database, displays, development of additional displays and reports for all signals related to Transformer, Bays etc. as per requirement. Furthermore, supply of Ethernet switches and other equipment for integration with existing SAS shall be included in the scope of the Contractor.

All SAS integration work should be carried out in presence of existing SAS OEM authorized personnel, arrangement of SAS OEM authorized personnel under the scope of the contractor.

Any upgradation of hardware and software for above integration shall be in the scope of contractor including license upgradation (if any).

Fire Protection System

Smoke detection, Fire alarm & Annunciation System for 132 kV GIS Hall (including Panel Rooms, AHU Room) and Control Room Building

The Fire Fighting panels shall be suitable for complete 132/33 kV substation. The fire alarm & Annunciation panels shall have sufficient capacity to accommodate the alarm signals arise from the 132/33 kV System.

Battery & Battery charger. The capacity of Battery & Battery charger shall be worked out by bidder for complete 132kV substation (including future bays). However, capacity of battery and charger should not be less than as specified in the BPS. If the calculated rating is more than that of the specified rating in BPS, the calculated rating battery shall be provided and the cost shall be quoted as such in the line item.

1.1kV grade Power & Control cables along with complete accessories, including power cables for oil filtration units with associated power receptacle. Cables from MB & RTCC of 132/33 kV, 50MVA Transformers to Control & Relay Panel/SAS also is covered under present scope of work.

Lattice and Pipe structures (galvanized): Towers, Beams and all Equipment support structures except support structure for circuit breaker. The Support structure for Circuit

Breaker shall be as per manufacturer's design. Contractor shall provide editable soft copies of design & drawings during detailed engineering. The design of support structures for GIS equipment, its ducts and SF6 to air bushing shall be designed by the GIS manufacturers.

In the bid price schedule, the structures including fasteners & foundation bolts are indicated in the form of LS. For design of Gantry structures, the conductor tension shall be considered based on actual requirement for present & future scope of work

In case of 132kV, the Gantry structures including fasteners & foundation bolts are required to be quoted per bay wise. In each bay, the bidder shall consider all required structures. Line take-off structures are shall be considered with ±30-degree deviation and slack span of maximum 100 m.

During SCF calculation, conductor shall be considered as twin zebra/moose with sub conductor spacing of 250mm and spacer – spacer spacing of 1.5 metres.

The lightning protection (DSLP) for complete switchyard is to be provided by the contractor. The contractor shall design the lightning protection by considering lightning masts of 50 metres high. If by using lightning masts the protection is not achieved, columns with peaks and shield wires shall be utilized for lightning protection purpose. The civil works shall be payable as per relevant item of BPS. Rolling sphere method/Razevig Method shall be considered for DSLP protection.

Erection Hardware: Insulator strings and hardware, Disc Insulators/Long Rod Insulators (as applicable), conductor(s), Al tube, bus-bar materials, cable trays & covers, Bay MB, spacers, clamps & connectors, junction box, earthwire, earthing material risers, auxiliary earthmat for Indoor GIS & outdoor AIS isolators (excluding main earth mat), buried cable trenches/pipes for equipment & lighting, cable supporting channels, Insulating mats, cable sealing arrangement, all accessories etc. as required

Main Earthmat and Main Earthmat Extension at Mariani END shall be provided under present scope of work. All the equipments structures, cable trenches, auxiliary earthmat for isolators, GIS etc. shall be earthed by connecting them to the main Earthmat.

Following considerations shall be taken care off while designing of transmission towers for proposed 132/33kV Titabor GIS:

1) 132kV D/C towers shall be designed to suit AAAC Single Panther conductor for wind zone-V.
2) Single circuit stringing (vertically on one side) shall be possible for 132kV D/C towers.
3) All the towers shall be designed to suit 96 fibre OPGW.

PHYSICAL AND OTHER PARAMETERS

Location of the Substation - The location of substation is indicated below:

Sr.No	Name of Substation	Name of State	Nearest Railway station
1.	Titabor Dist-Jorhat	Assam	Mariani
2.	Mariani Dist-Jorhat	Assam	Mariani

Meteorological data

The meteorological data are as below:

S.No.	Station Meteorological parameters	Parameter Value
1	Snow Fall	Not applicable
2	Wind Zone	Wind zone-5
3	Seismic Zone	Zone-V
4	Design Ambient Temperature	50 degree centigrade
5	Minimum temperature	0 degree centigrade
6	Altitude	1000 mm
7	Coastal Area Consideration	No

Fault level shall be considered as mentioned below:-

Sl. No.	Name of Substation	132kV	33kV
1.	Titabor	40kA for 3 Sec	31.5kA for 3 Sec
2.	Mariani	40kA for 3 sec	-

Establishment of new 132/33 kV AIS S/S at Chabua

Design, engineering, manufacture, testing at manufacturer's works, supply including transportation and insurance, unloading, storage, erection, testing and commissioning at site for the following equipment/items, complete in all respects:

<u>**132kV Section**</u>

132kV Bus shall be Twin ACSR Moose in double main cum transfer arrangement and shall be as per the drawings.

<u>**33kV Section**</u>

33kV Bus shall be 3 Inch IPS Aluminum Tube with Necessary Support structures as per detail engineering. The 33kV Outgoing Bays shall be as per the drawings and BPS.

Testing and Maintenance Equipment as per **BPS** (Bid Price Schedule).

Mandatory Spares as per **BPS** (Bid Price Schedule).

Any other equipment/material required to complete the specified scope of work shall be quoted in the relevant line item of the BPS.

The Control & Relay Panel room shall accommodate all the present and future control and protection panels along with PLCC, FOTE and FDA panels. Ladders shall be provided for movement of personnel to the top of the relay room for any maintenance related work.

SAS room in the control room building shall be in such a position so that all the switchyards i.e. 132 and 33kV along with the transformers are visible from the SAS room. SAS panels, Gateway Panels, Aux BCU panels etc. shall be housed in the SAS room. A proper and robust lifting arrangement (hydraulic/chain pulley) shall be provided for easy lifting of the SAS panels from the ground level to the first floor.

Other Main Equipment

Integration of IEC61850 communication based monitoring equipment's like On-line Insulating Oil drying system, Digital RTCC relays, etc. {as applicable for 220/132 kV, 3-Phase Autotransformer, with substation automation system is also included under present scope

Further the contractor shall also supply necessary BCUs for control and monitoring of substation auxiliary system. SAS server & gateway shall have licenses sufficient for all, bays (i.e. present scope bays and all future scope bays as applicable).

Integration of Line Bays under present scope with existing Sub Station Automation System for MHMI and RHMI:

The scope of the Bidder shall include but not limited to integration of IEDs under present scope of construction with the existing substation automation as per tender drawings and documents, which is based on IEC 61850 and capability enhancement of same as required including up-dating of system database, displays, development of additional displays and reports for all signals related to Transformer, Bays etc. as per requirement. Furthermore, supply of Ethernet switches and other equipment for integration with existing SAS shall be included in the scope of the Contractor.

All SAS integration work should be carried out in presence of existing SAS OEM authorized personnel, arrangement of SAS OEM authorized personnel under the scope of the contractor.

Any upgradation of hardware and software for above integration shall be in the scope of contractor including license upgradation (if any).

Fire Protection System

Smoke detection, Fire alarm & Annunciation System for Control Room Building

The Fire Fighting panels shall be suitable for complete 132/33 kV substation. The fire alarm & Annunciation panels shall have sufficient capacity to accommodate the alarm signals arise from the 132/33 kV System.

Battery & Battery charger. The capacity of Battery & Battery charger shall be worked out by bidder for complete 132kV substation (including future bays). However, capacity of battery and charger should not be less than as specified in the BPS. If the calculated rating is more than that of the specified rating in BPS, the calculated rating battery shall be provided and the cost shall be quoted as such in the line item.

1.1kV grade Power & Control cables along with complete accessories, including power cables for oil filtration units with associated power receptacle. Cables from MB & RTCC of 132/33 kV, 50MVA Transformers to Control & Relay Panel/SAS also is covered under present scope of work.

Lattice and Pipe structures (galvanized): Towers, Beams and all Equipment support structures except support structure for circuit breaker. The Support structure for Circuit Breaker shall be as per manufacturer's design. Contractor shall provide editable soft copies of design & drawings during detailed engineering.

In the bid price schedule, the structures including fasteners & foundation bolts are indicated in the form of LS. For design of Gantry structures, the conductor tension shall be considered based on actual requirement for present & future scope of work

In case of 132kV, the Gantry structures including fasteners & foundation bolts are required to be quoted per bay wise. In each bay, the bidder shall consider all required structures. Line take-off structures are shall be considered with ±30-degree deviation and slack span of maximum 100 m.

During SCF calculation, conductor shall be considered as twin moose with sub conductor spacing of 250mm and spacer – spacer spacing of 1.5 metres.

The lightning protection (DSLP) for complete switchyard is to be provided by the contractor. The contractor shall design the lightning protection by considering lightning masts of 50 meters high. If by using lightning masts the protection is not achieved, columns with peaks and shield wires shall be utilized for lightning protection purpose. The civil works shall be payable as per relevant item of BPS. Rolling sphere method/Razevig Method shall be considered for DSLP protection.

Erection Hardware: Insulator strings and hardware, Disc Insulators/Long Rod Insulators (as applicable), conductor(s), Al tube, bus-bar materials, cable trays & covers, Bay MB, spacers, clamps & connectors, junction box, earth wire, earthing material risers, auxiliary earthmat for Indoor GIS & outdoor AIS isolators (excluding main earth mat), buried cable trenches/pipes for equipment & lighting, cable supporting channels, Insulating mats, cable sealing arrangement, all accessories etc. as required.

Following considerations shall be taken care off while designing of transmission towers for proposed 132/33kV Chabua S/s:

1) 132kV D/C towers shall be designed to suit ACCC Casablanca conductor for wind Zone-V.
2) Single circuit stringing (vertically on one side) shall be possible for 132kV D/C towers.
3) All the towers shall be designed to suit 96 fibre OPGW.

PHYSICAL AND OTHER PARAMETERS

Location of the Substation - The location of substation is indicated below:

Sr.No	Name of Substation	Name of State	Nearest Railway station
1.	Chabua Dist-Dibrugarh	Assam	Chabua/ Dibrugarh
2.	Dibrugarh Dist-Dibrugarh	Assam	Dibrugarh
3.	Tinsukia Dist- Tinsukia	Assam	Tinsukia

Meteorological data

The meteorological data are as below:

S.No.	Station Meteorological parameters	Parameter Value
1	Snow Fall	Not applicable
2	Wind Zone	Wind zone-5
3	Seismic Zone	Zone-V
4	Design Ambient Temperature	50 degree centigrade
5	Minimum temperature	0 degree centigrade
6	Altitude	1000 mm
7	Coastal Area Consideration	No

Fault level shall be considered as mentioned below: -

Sl. No.	Name of Substation	132kV	33kV
1.	Chabua	40kA for 3 Sec	31.5kA for 3 Sec
2.	Dibrugarh	40kA for 3 sec	-
3.	Tinsukia	40kA for 3 sec	-

2.7 Right of Way for Transmission Lines:

2.7.1. The contractor should adhere to policy & internationally recognized standards (Indian Standards, IEEE and IEC standards) in design and construction of facilities, laying of transmission lines, support infrastructure and in selection of equipment. Further, the contractor’s endeavor should be to avoid habitations and densely populated areas while selecting route alignment. The Contractor shall also ensure that the route of the transmission line does not impact adversely on the cultural life of the tribal and indigenous population of the localities. Maintenance of ecological balance shall be the essence of the selection of the route for transmission line.

2.7.2. The contractor should also adhere to clearance norms prescribed in Indian Electricity Rules for: (a) clearance above ground for lowest conductor; (b) vertical clearance from buildings; (c) horizontal clearance from buildings; (d) minimum clearance between lines crossing each other; and (e) minimum clearance prescribed for live equipment in outdoor sub stations.

2.7.3. Any right of way that may be required for execution of transmission line shall be arranged by the Contractor in favour of AEGCL.

2.7.4. For obtaining clearances from concerned departments and persuasion with the landowners to resolve the Right of Way issues are the responsibility of the Contractor. AEGCL will provide necessary assistance in obtaining aforesaid clearances from Government authorities, if required. For obtaining the clearances for Road, Railway, Power line crossings, PTCC clearance etc the Contractor shall be responsible for preparation and submission of requisite proposals following the standard norms of the appropriate authorities at appropriate time and follow up with the concerned department till approval is obtained for execution within the scheduled time. AEGCL may assist in this process. The requisite charges/fees/ compensation at actual to be paid to the Government departments will be paid directly either by AEGCL or by the Contractor on behalf of AEGCL to the Govt. Department. In the event of the bill being paid directly by the Contractor the same bill in original duly signed by the concerned officials of district Administration/ Concerned Office shall be forwarded to AEGCL for reimbursement.

2.7.5. Identification and demarcation of defence, airport areas and forest land, and plotting, preparation of proposals with necessary drawings/schedules is the responsibility of the Contractor. Submission of such proposals to the State Govt./Central Govt. departments shall be routed through the AEGCL. However, the requisite charges/fees/compensation at actual to be paid to the Government departments will be paid directly by AEGCL to such govt department after the said bill signed by the concerned officials of concerned department is forwarded to AEGCL by the Contractor. For forest clearance, the Contractor shall prepare the required documents and upload in the portal of Forest department. The Contractor and AEGCL shall jointly follow up further till the statutory clearance are obtained.

2.7.6. Access roads to the work site shall be arranged by the contractor at his cost. All necessary compensation in this respect shall be borne by the Contractor.

2.1.7 The Contractor shall be responsible for compliance of all contractual liabilities which includes financial, legal and administrative issues as required in solving Right of Way during execution of the lines.

2.7.8 The Contractor shall make all required liaisons and accompany the concerned Revenue Authority for assessment of affected properties (both land and zirat) and shall take help of other Departments like PWD, Agriculture, Veterinary, Horticultures etc wherever deemed necessary for working out the compensation amount. For that purpose, the notification issued by the Govt of Assam No.PEL.219/2015/91dated10/03/2017 shall be strictly followed in conjunction with the Electricity Act 2003, The Telegraph Act 1885 and other relevant State /Central Acts. The contractor shall be liable for giving all assistance to concerned District Administration for preparation of valuation reports, estimates, provisional notice, compensation receipts and any other documents as per standard GOA or AEGCL formats. The contractor shall also make all necessary arrangements for joint survey of the land and zirat assessment with concerned officials of District administration, officials of Govt. of Assam and officials of AEGCL.

2.7.9 Any avoidable or deliberate damage done to any property by the contractor's labourers shall be the sole responsibility of the contractor and the contractor shall pay any compensation in this regard to the affected party directly without creating any liability on the part of AEGCL.

2.7.10 Any compensation against damage caused due to storage/dumping of materials by the contractor shall be the sole responsibility of the contractor and the contractor shall pay any compensation in this regard to the affected party directly without creating any liability on the part of AEGCL.

2.7.11 AEGCL shall not be responsible for arranging access roads/RoW for transport of material from roadside to worksites. If the contractor has to adopt any such arrangements, he may do so with the consent of the property owners and any compensation in that respect shall be his responsibility against which no reimbursement shall be made by AEGCL. The contractor shall take all necessary precautions to cause no/minimum damage while executing work.

2.7.12 Clearing of obstruction falling in the right-of-way to maintain standards asperIS:5613(Part-3, Section-2),1985 and lopping and trimming of trees and other overgrowths during check survey or work execution shall be under contractor's scope. Arrangement of required documents, obtaining Govt. department permissions and submission of necessary fees shall be done by the contractor. AEGCL shall assist in the official procedures wherever deemed necessary and any statutory fees incurred by the contractor in obtaining statutory clearances/permissions at this stage by the contractor shall be reimbursed in due course of time on submission of valid documentary evidence.

2.7.13 The Acquisition of land for Sub- Stations shall be the sole responsibility of AEGCL. Whereas the Contractor shall be responsible for securing the RoW for transmission line works, AEGCL shall assist the Contractor for getting clearances from Railway, NHAI, Forest, Water, and other Govt./Statutory bodies. All statutory fees for getting clearance shall be to AEGCL's account.

2.7.14 For settlement of ROW for private lands (including private water bodies), the clearances shall be extracted by the contractor based on the RoW notified by the Government. The land compensation amount shall be settled by the contractor through district revenue officials based on relevant provision of the GOA guidelines and as per the mechanism followed by district administration for assessment/fixation of land compensation. However, the compensation amount will be paid by AEGCL directly to the landowners on submission of Original award statement by the contractor to AEGCL against such land, duly assessed and signed by the concerned officials of District Revenue Administration. The acknowledgement for receipt of the amount by the landowner shall be through Non-Judicial stamp paper.

2.7.15 For zirat compensation on account of crop damage, plantation damage, tree cutting etc the assessment shall be done jointly by the contractor and AEGCL officials in coordination with the district/revenue officials. Based on this assessment, the zirat payable to the beneficiaries shall be fixed and the same shall be paid to the beneficiaries by the contractor through district administration. The contractor shall then submit the Zirat bills duly endorsed by the concerned revenue official to AEGCL for reimbursement. The reimbursement of the compensation shall be made by the AEGCL within 30(thirty) working days from the date of submission of the bills.

2.7.16 For the purpose of any reimbursements, requisition shall be placed at AEGCL, HQ through proper channel and in the form of passed bills (passed at respective field offices) along with 2(two) sets of documents with necessary signatures as mentioned below:

a. Provisional Notice
b. Assessment Estimate endorsed by the concerned revenue official
c. Journal voucher
d. Acknowledgement of payment receipt

Signatures of Circle Officer, Project Manager, Accounts Officer and other Field Officials (if any) are mandatory in the bill.

2.7.17 Statutory Clearances: It is the sole responsibility of the contractor to follow the standard clearances mentionedintheIndianElectricityRules1956 while execution of any works related to construction and energization of a transmission line. The contractor shall be responsible for obtaining documents/drawings/designs/maps etc making liaisons with local governmental bodies and making payments to concerned offices for obtaining approvals against statutory clearances. The contractor shall make themselves properly acquainted with all the prevalent governmental guidelines/notifications/regulations/documentary and monetary requirements as well as official procedures well in advance for ensuring no delay in work progress. AEGCL shall reimburse the amount incurred by the contractor while paying for statutory fees on submission of valid documentary evidences. The statutory clearances for which approvals are to be obtained are mentioned below:

(i) PTCC
(ii) Railways
(iii) Airport Authorities
(iv) Electrical Inspector
(v) NHAI
(vi) Any other clearances as deemed necessary

Fees for Compensatory Afforestation, Forest Rights, etc shall be paid directly by AEGCL

2.7.19 All Compensation related payments shall be made by means of Cheques only. It is the responsibility of the contractor that prior to payment, all the documents are rechecked, and payments are made without undue delay so as to win the trust of the land-owners on AEGCL’s activities thereby paving the way for faster and smooth progress of work.

2.7.20 The contractor shall be deemed to have made himself acquainted with any other specific difficulty associated with the site and work accordingly.

The contractor shall provide necessary support for documentation.

2.7.21 Moreover, concerned AEGCL officers at field level shall monitor the overall proceedings of the work execution for ensuring the compliance of approved technical standard.

2.7.22 The Contractor shall be eligible for reimbursement of expenses incurred for Court Cases and Police support for critical RoW issues. The reimbursement of these expenses shall be made by AEGCL within 30(thirty) working days from the date of submission of the documents.

2.7.23 AEGCL may agree on extension of time as deemed fit by it for completion of a part of the entire work without levying any Liquidated Damages, if any delay in obtaining clearances & ROW as mentioned above for reasons beyond the control of the Contractor provided that such delay shall not compromise the time schedule for completion of the project as stipulated in Section -3 of Vol-I of this Bid.

2.7.24 The key social and environmental aspects that are / may be associated with the Project relate to AEGCL's environment and social assessment, corporate environmental, social and health and safety management system and their implementation. In the context of the Project, the key social and environmental issues, which will have to be managed under environment and social management system include: impacts on households due to restrictions/ constraints in the proposed ROW, crop damage and loss of trees during construction / maintenance; employee and community health and safety impact during construction and operation; community consultation and engagement; labor working conditions including employee and contract labor health and safety; impacts due to emissions to soil, air and water during construction and operation ; and potential impacts on biodiversity and cultural heritage.

However, the project 's impacts are mostly short term, limited to the Projects its, reversible and limited impact, if unavoidable, on environmentally sensitive areas. Further, it is possible to readily design and implement engineering and management measures to mitigate adverse impacts. The Charges for Implementation of the above shall be reimbursed to contractor by AEGCL at actuals.

For schedule of quantities, refer **CHAPTER 2 OF** "**Volume III – BID PURPOSE DRAWINGS, SCHEDULE OF QUANTITIES AND MISCELLANEOUS DOCUMENTS"**

CHAPTER 3: DRAWINGS AND DOCUMENTS

The contractor will furnish drawings/ documents as per attached drawing schedule. Circulation of drawings/ documents shall be strictly followed during contract stage. Any equipment purchased by the contractor without the approved drawing will be treated as a breach of contract. The drawings/Documents which require the Employer's approval shall be as per the under mentioned sequence:

i. Submission of drawings shall begin within 45 days from award of contract.

ii. AEGCL shall convey the approval / acceptance/ rejection /observations on these drawings & documents within 20 days.

iii. Resubmission of drawings shall be made within 10 days.

iv. The same sequence shall follow till final approval, but contractor shall make best efforts to obtain approvals in first submission in order to avoid delays in approval & project execution.

v. 6 sets of drawings in white plots in AutoCAD of 2007 version or above and readable and editable softcopies shall be submitted for approval till approval is obtained.

vi. 6 sets of AS-BUILT drawings shall be submitted along with softcopies.

vii. 6 sets of hard copies of drawings shall be submitted to the design wing of AEGCL (civil and electrical) for necessary checking.

viii. Drawing has to be submitted in sequence as per list of drawings as Approved by Employer's.

ix. The list of drawings and documents has to be submitted by EPC for approval of Employer's.

LIST OF DRAWINGS TO BE SUBMITTED AFTER AWARD OF CONTRACT

(i) All the electrical equipments to be supplied have to be of reputed makes. The equipment of those manufacturers, who have sufficient proven experience of manufacturing the respective equipment of similar capacity, shall be considered. The respective equipment should have been manufactured, supplied, installed, commissioned successfully and should be running satisfactorily since at least last 5 years continuously. If for a specific item the requirement is beyond 5 years in that particular specification the same shall be applicable. Certificates from the end users, regarding their satisfactory Performances shall have to be submitted in this regard.

(ii) Following drawings, calculations & schedules shall be submitted for approval before procurement, fabrication and Installation of equipments at site,

S. N	Drawings
1.0	Single Line Diagram of Complete Electrical System based on the design criteria.
a.	Substation layout/plot plan in section and plan.
2.0	Cable Sealing Ends for cables above 33kV cables
a.	Complete assembly drawing showing plan, elevation and sectional views of CSE showing the internal construction and incorporating mounting dimensions, overall dimensions, material of construction, cables joints, SVL, weight, electrical clearances for installation, details of terminal connections etc.

b.	Calculations and General arrangement drawing of the foundations of structure mountings and structure.
3.0	Lightning Arrestor (33kV and above)
a.	Complete assembly drawing showing plan, elevation and sectional views of arrester showing the internal construction and incorporating mounting dimensions, overall dimensions, material of construction, weight, electrical clearances for installation, details of terminal studs etc.
b.	Ratings and description of special features, if any.
c.	Power frequency voltage vs. time characteristic of the arrester.
d.	Drawings for Surge counter, grading ring, porcelain bushing, terminal clamp, pressure release arrangement and rating plate.
e.	Guaranteed Technical particulars, type test certificates
f.	Calculations and General Arrangement drawing of the foundations of structure mountings and structure.
4.0	BPI (33kV and above)
a.	Complete assembly drawing showing plan, elevation and sectional views of Insulator incorporating mounting dimensions, overall dimensions, material of construction, weight, details of terminal studs etc.
b.	Guaranteed Technical particulars, type test certificates
c.	Calculations and General arrangement drawing of the foundations of structure mountings and structure.
5.0	Clamps and Connectors (33kV and above)
a.	Detailed dimensioned drawings for Clamps & Connectors giving weight, rating, bill of material including bolts, nuts, washers, etc.
6.0	Earthing details of Substations and Transmission lines including calculations and layout drawings.
a.	Complete DSLP calculation with related drawings.
7.0	Civil Details for switchyard including fencing, officers hostels, staff hostel, secutity barrack, transit camp, RE residence, Store Building, 33kV control room building , security gate and all other related civil works.
8.0	Substation HVAC System
a.	Providing Ventilation system of the Exhaust air fans for Ground Floor 400/220/132 KV GIS Room & 33 kV Switch Gear Room, cable trench, Battery Room, Store Room, Kitchen / Pantry, Lockers & Toilet.
b.	Providing Air Conditioning system for the Conference Room, Admin Room-1, Admin Room-2, Admin Room-3, Battery Room, Digital PLCC Room, SCADA & CRP Room, Office Room-1 and Office Room-2.
C	Providing location for Fresh and Exhaust air Louvers wherever necessary.
9.0	Electrical Substation GA and sectional Layouts of 400/220/132kV GIS showing locations of various Equipment including, Transformer, cable trenches, Switchgear Panel, control & relay panels and other allied equipments and associated systems as listed above.
10.0	**GIS (132kV and above)**

a.	General Arrangement and sectional drawings of overall layout of GIS, terminal arrangement, bay cross section of individual bays, LCP, PD monitoring system including all dimensional details, layout and maintenance requirements, details of supports required for piping and other accessories, cable entry details, Grounding requirements, etc
b.	Foundation drawings for all equipment/accessories indicating the grouting details, static and dynamic loading data and any insert details for supporting structures and other equipment
c.	Gas Section diagram, Guaranteed Technical Particulars.
d.	Schematic wiring diagrams & Block interlock diagrams indicating the control and interlock logic for all equipment/accessories
e.	Bill of materials listing equipment designation, make, type, rating, etc. of the various equipment mounted on the equipment.
f.	Type test certificates not older than ten years and submit certificates before award of contract (if already not submitted).
g.	All Routine tests shall be conducted on each equipment.
h.	Descriptive and illustrative literature for the equipment
11.0	Relay & Control Panel (33kV and above)
a)	Control and relay panel drawing showing plan, front elevation, foundation details, floor openings, terminal block location, etc.
b)	Schematic wiring diagrams
c)	Bill of materials listing equipment designation, make, type, rating, etc. of the various equipment mounted on the panels.
d)	Interconnection and external connection wiring drawings - The drawings shall include all panel to panel interconnections and panel to field external connections to facilitate external cable connections.
e)	Type test certificates & Routine test certificates not older than five years and submit certificates before award of contract.
f)	All Routine tests shall be conducted on each equipment.
g)	Descriptive and illustrative literature for the Relays, Instruments, Meters, Annunciators, Control Switches, etc.
12.0	General arrangement for MRS (Main receiving substation)
a)	G A drawing for 33kV & above substation showing GIS, battery/battery charger and DCDB, PCC, ACDB, 400/220kV, 220/33kV, 220/132kV, 132/33kV Power transformer, station transformer and cabling, earthing, lighting and lightning protection layouts.
13.0	Bill of quantities for GIS Substation (33kV and above)
14.0	220/34.5kV & 33kV/0.433kV Transformers (33kV above)
a.	General arrangement drawing shall indicate the overall dimensions, net weights, quantity of oil, crane requirements for assembly and dismantling of transformers, and the general constructional features.
b.	General arrangement drawing of the transformer showing plan, front elevation and side elevation complete with all accessories and fittings, detailed dimensions, cable entries, earthing terminals, foundation/floor fixing details, jacking pads, crane lift for un tanking, size of lifting lugs and eyes, clearances between HV terminals, between LV terminals, between HV and LV terminals, between HV & LV terminals and ground and bill of materials etc.

c.	Valve schedule, Rating, diagram and terminal marking plates, complete with polarity and vector group.
d.	OLTC cabinets: schematic circuit diagram and actual detailed wiring diagram giving terminal numbers.
e.	Bushings Plan, elevation, terminal details, mounting details, make and type number, current and voltage rating, creepage distances and principal characteristics.
f.	Control wiring diagram for marshalling box.
g.	RTCC Panels GA & detailed Schematic drawings
h.	NIFP System GA drawing with detailed P&ID Drawings
i.	QAP
15	**Power Transformers**
A	Complete GA drawing in section and plan.
B	Transformer foundation along with all related civil drawings.
C	OLTC GA drawing with complete details.
D	RTCC, Bushing, winding details, bushing CT details, cooler details drawings.
E	Fire wall and Fire fighting arrangement drawings.
16.0	415V Main PCC/ ACDB/ Sub ACDB Panels/ Emergency/ UPS/ Lighting DB's
a.	Complete assembly drawings of the switchboard/distribution board showing plan, elevation and typical sectional views and location of cable boxes and control cable terminal blocks for external wiring connections.
b.	Foundation plan showing the location of channel sills, foundation, anchor bolts and anchors, floor plans and openings.
c.	Schematic power, Feeder operation logic and control wiring diagrams with control, interlocks, relays, instruments, space heaters, starters with Bi-metallic relay ratings and contactor ratings, busbar rating with material etc.
d.	Details of breakers, relays and other components as may be incorporated.
e.	Type test certificates not older than last five years and submit certificates before award of contract.
17.0	**Battery & Battery charger with DC Distribution Board**
a.	Dimensioned general arrangement drawings
b.	Fully dimensioned general arrangement drawings of battery and battery charger with elevation, side view, sectional view and foundation details
c.	Complete schematic and wiring diagrams
18.0	**Cabling system**
a.	Details of Installation of Cables in Trenches/Tunnels, on cable trays, racks directly buried etc., at all locations as specified including cable trays.
b.	220 kV, 132kV, 33kV & 1.1kV Cable routing layout inside and outside the Switchyard.
c.	Bill of quantities of LT cables, lugs and glands & HT Termination Kits.
d.	All Cable termination and mounting Kit Layout drawing.
e.	Cable Termination arrangement drawing (33kV & above).
19.0	Earthing & Lightning Protection system

a.	Detail calculations of earthing network including step & touch calculations, main grid calculations.
b.	Earthing notes including detail write up and drawings of earthing conductor layout, equipment & structural earthing, joints, cable earthing, instrument earthing and special earthing.
c.	Details such as material, sizes, etc. of the earth conductor and electrode pits
d.	Earthing layout drawing showing routing of main grid inside and outside of Building with interconnection of equipment earthing to the grid and earth pits
e.	Lightning protection layout along with DSLP calculation.
20.0	Lighting System for MRS Building & outdoor areas
a.	Detailed Room wise Lighting Layout with Type of fixture details and Circuit diagram showing phase wise load distribution and interconnection between switches, fixtures, Lighting panel, receptacles etc & Detailed lux level calculations.
b.	Conduit layout showing room wise routing of wires from lighting panel to lighting fixtures, receptacles etc.
c.	Internal road Lighting and Area lighting layout with type of mounting details and fixture details.
21.0	**SCADA**
a.	SCADA Architecture drawings with details
b.	Functional design specifications
c.	Factory acceptance test
22.0	Civil Structural Drawings Related to Gantry.
23.0	All Civil drawings related to Buildings & foundations of all the electrical items (both GIS and AIS)
24.0	All Civil Drawings related to Site Grading, Internal Roads including Storm Water Drains & Footpaths including necessary calculations.
25.0	Drawing for the Fencing of the entire substation plot including necessary calculations.
26.0	Drawings for Fire fighting, HVAC, Plumbing, SCADA System and Fire alarm system
27.0	Drawing for pump house (colony & HVWS), water tank, parking shed, Gate, Boundary wall, Lighting Mast, Fire protection wall for Power Transformers
28.0	Drawings for switchyard cable trenches and Control room cable trenches.
29.0	Layout for switchyard PCC and gravelling.
30.0	Drawing for contour plan and marking the existing HFL with earth filling required at the substation location.
31.0	Drawings for Reactors including wiring schematics.
B)	**Calculations**
	All related Power Transformer design calculation details as described in respective specification.
a.	Auxiliary Transformer Sizing Calculations
b.	Fault level Calculations

c.	Co-ordinated protection study with latest available version of PSSE software.
d.	HT & LT cable sizing
e.	UPS & Battery Sizing Calculations
f.	Switchyard Lightning Protection and Earthing Sizing Calculations
g.	Room wise Lighting Calculation as per Lux level given in IS 3646 Part-I.
h.	Calculations related to Fire fighting, HVAC, Plumbing, SCADA System and Fire alarm system
C)	**Schedules**
a.	Cable Schedule
b.	Protection Relay Setting Schedule
c.	Interconnection schedule
d.	Junction Box Schedule

Note:

1. All other documents listed in the particular specification of each equipment, but not listed above shall also be submitted.
2. All equipment/ system sizing calculations/ drawings shall be submitted to the employer for approval whether specifically mentioned or not.

CHAPTER 4: PROJECT IMPLEMENTATION

GENERAL CONDITIONS

4.1 Responsibility of the Contractor

The Contractor shall also be responsible for the complete design and engineering of substation, overall co-ordination with internal and external agencies, project management, training of Employer's manpower, loading, unloading, storage at site, inventory management at site during construction, for successful erection, and testing and commissioning of the substation as per the **CHAPTER 2 OF** "**Volume III – BID PURPOSE DRAWINGS, SCHEDULE OF QUANTITIES AND MISCELLANEOUS DOCUMENTS"**

Contractor has to be construct site office as well provide separate site office for employers as well PMC.

The Contractor shall construct the works in compliance with the outline programme appended to the Bidding Document, and shall submit for the approval of AEGCL, a detailed programme in accordance with the requirements of this Specification.

Programme:

1) All activities from the start Date up to commissioning shall be included. Separate Programme shall be furnished for each of the activities.

2) Earliest and latest occurrence of each activity.

3) Constraints, if any.

The activities for each of the items shall essentially cover time-table for activities such as placement of order with sub-vendors, Empowering, submission of drawing, review and approval by the Employer, manufacture, inspection, delivery, erection and commissioning. All events shall be represented in a proper in proper sequence of occurrence with due consideration for inter-dependent activities and all period shall be counted from the start date.

Contractor to follow the ESIA report as per **CHAPTER 3 OF** "**Volume III – BID PURPOSE DRAWINGS, SCHEDULE OF QUANTITIES AND MISCELLANEOUS DOCUMENTS"**

4.2 Specific exclusions:

The following items of work are specifically excluded from the Contractors scope of work unless otherwise specifically brought out.

a) Substation site selection

b) Land acquisition for substation

4.3 Interfacial point for line termination at substation

The Contractor shall terminate the transmission line along with insulator hardware and other essential fittings at the substation gantry. The Contractor shall provide necessary anchoring plates etc.

4.4 Limit of Contract

Whether called for specifically or not, all accessories and work required for the completion of the work are deemed to be considered as a part of the Bidder's scope, unless and until mentioned very clearly as excluded. The scope of work shall also include all work incidental for successful operation and commissioning and handing over of works whether specifically mentioned or not. In general works are to be carried out by the Contractor in accordance with stipulations in Conditions of Contract.

4.5 Meteorological data

Appropriate meteorological data is given in the **CHAPTER 2.**

4.6 Soil data

The general characteristics of the soil are given in the **CHAPTER 3 OF** "**Volume III – BID PURPOSE DRAWINGS, SCHEDULE OF QUANTITIES AND MISCELLANEOUS DOCUMENTS"**. The information furnished is for reference purpose only. The Contractor shall be required to carry out soil investigation and related design based on his findings.

4.7 Completeness and accuracy of information

The Contractor shall note that the information provided above and in the relevant schedules may not be complete or fully accurate at the time of bidding. For his own interest the Contractor is advised to make site visits and fully satisfy himself regarding site conditions in all respects and shall be fully responsible for the complete design and engineering of the substations.

4.8 Drawings attached with Tender Document

The various drawings and schedules provided are a part of the specification and for information purposes only. These are not necessarily binding on the part of the Contractor. However, the Bidders shall inspect the site and prepare the topographic map with proper contour lines. The layout shall be drawn on the basis of this topographic map. The layout of the substation shall then be superimposed on the prepared topographic map and the same shall be submitted to AEGCL for approval. The Drawings provided are enclosed in **CHAPTER 1 OF** "**Volume III – BID PURPOSE DRAWINGS, SCHEDULE OF QUANTITIES AND MISCELLANEOUS DOCUMENTS"**

4.9 Guaranteed Technical Particulars

The Contract Works shall comply with the guaranteed technical particulars specified or quoted in the bid. All plant and apparatus supplied under this Contract shall be to the approval of AEGCL.

All plant and equipment supplied under this contract must have been type tested (as per IEC standard) as specified in the respective specification as on date of bid opening. And have been in manufacture and satisfactory service at Same or Higher rated equipments ratings for at least five years for Power Transformers and 7 years for GIS equipments. The bidder shall furnish in his bid the necessary supporting data in specified formats for consideration during bid evaluation. If during evaluation noncompliance is identified the successful Contractor shall be bound to supply the equipment from manufacturers complying with the stipulated requirements / AEGCL approval renders.

Validity of type test reports conducted on major electrical equipment shall be as per guidelines of Central Electricity Authority (CEA) vide file no. CEA-PS-14-80/1/2019-PSETD Division-Part(2) dated May 2020.

The Contractor shall be responsible for any discrepancies, errors or omissions in the particulars and guarantees.

The Bidder for his own interest, shall establish the technical responsiveness of his bid, shall provide all data in appropriate technical data sheets, general/ technical information, literature, and pamphlets etc. along with the bid.

4.10 Compliance with Specification

All apparatus should comply with this Specification. Any departures from the requirements of this Specification shall be stated in the relevant Bid Proposal Schedules and will be considered during Bid evaluation. Unless brought out clearly in the technical schedules, it will be presumed that the equipment is deemed to comply with the technical specification. In the event of there being any inconsistency between the provisions of the conditions of contract and the provisions of this Specification in respect of commercial requirements, the provisions of the conditions of contract shall take precedence for commercial matters and the provisions of this Specification shall take precedence in respect of technical matters. In case of inconsistency between technical specification & bid proposal sheet, quantities of various items as specified in the bid proposal sheet shall be considered for quoting however the work shall be executed as specified in the technical specification. Only brief description is given in the BPS & the work shall be executed in line with the requirement given in the technical specification. The manufacturer and places of manufacture, testing and inspection of the various portions of the Contract Works shall be stated in the relevant Bid Proposal Schedules.

4.11 Test and Maintenance Equipment

The Contractor shall supply the type and quantity of test and maintenance equipment specified in the Schedules as part of the contract works.

4.12 Spares

4.12.1 General

The Contractor shall provide the mandatory spares detailed in the Schedules. Provide a list of recommended spare parts (optional spares) together with their individual prices, which will be considered forfor evaluation. The Employer may order all or any of the Optional spare parts listed at the time of contract award.

Mandatory spares shall be supplied as part of the Works under this specification. Additional spares (Mandatory) may be ordered at any time during the contract at the rates stated in the Price Schedule.

4.12.2 Mandatory spares

The Employer has indicated the requirement of mandatory spares in **CHAPTER 2 OF** “**Volume III – BID PURPOSE DRAWINGS, SCHEDULE OF QUANTITIES AND MISCELLANEOUS DOCUMENTS”.** These quantities shall be considered for evaluation of the bids.

4.12.3 Optional spares (shall not be considered for evaluation purpose).

The Contractor may recommend a list of optional spare parts together with the quantity and usage rates for their equipment in the relevant Bid Proposal Schedule. AEGCL shall assess their requirement and place orders.

The spares shall include consumable items sufficient for a plant operational period of five years after commissioning, as well as essential replacement parts to cover the event of a break-down which would affect the availability or safety of the plant. Spares shall be available during the life of the equipment and the Contractor shall give 12 months’ notice of his, or any sub-contractor's, intention to cease manufacture of any component used in the equipment.

The Contractor shall ensure that sufficient spare parts and consumable items are available for his own use during commissioning of the plant. Spares ordered by the Employer shall not be used by the Contractor without the written consent of AEGCL and any spares so used by the Contractor during the commissioning of the plant shall be replaced by the Contractor at the Contractor's expense.

Any spare apparatus, parts and tools shall be subject to the same specification, tests and conditions as similar material supplied under the Scope of Works of the Contract. They shall be strictly interchangeable and suitable for use in place of the corresponding parts supplied with the plant and must be suitably marked and numbered for identification and prepared for storage by greasing or painting to prevent deterioration.

All spare apparatus or materials containing electrical insulation shall be packed and delivered in cases suitable for storing such parts or material over a period of years without deterioration. Such cases shall have affixed to both the underside and topside of the lid a list detailing its contents. The case will remain the property of the Employer.

4.13 Training

The Contractor will be required to provide suitable training for selected staff both on site and at the Contractor's place of work. Details of the training considered appropriate shall be stated clearly, at the bidding stage, based on the number of trainees specified. The cost of training including all course fees shall be included.

The areas in which it is considered training should be provided, and duration of the training courses, are given in this section. Alternative arrangements, where considered appropriate, should be suggested.

Four categories of training are considered appropriate namely:

I. Hardware maintenance.

II. Operator familiarisation.

III. Software management.

IV. Installation and commissioning techniques.

The contractor shall impart one-month field training & fifteen days factory training on GIS equipment for operation and maintenance of GIS substation. The bidder (in case of not a GIS manufacturer) shall obtain undertaking in the letter head of the GIS manufacturer from GIS manufacturer in this regard and shall enclose the same in the bid.

4.13.1. Hardware maintenance

Courses for hardware maintenance shall identify techniques for preventative physical maintenance and for identification, isolation and replacement of faulty components. This course shall take place before equipment is delivered to site.

An essential part of the hardware maintenance course shall include highlighting the philosophy of computer based preventive maintenance and identification of the various diagnostic/interrogation facilities available. The Contractor shall supply adequate documented instructions to enable a detailed interrogation and analysis process to be carried out using the diagnostic software facilities. All items of hardware to be supplied shall be covered by the course.

4.13.2 Operator familiarisation

This course is intended to familiarise the operators with the system and its use in substation operation and maintenance inclusive of associated communication network. The course shall ensure that the control room staff are completely familiar with all operational and maintenance aspects of the equipment. The means of obtaining special data, report logs and all other facilities which would enable the operators to be fully conversant with the system, shall also be incorporated.

It is envisaged that it will be necessary for the Contractor to run operator familiarisation courses each of approximately one week in duration at site for the training of the Employer's staff.

4.13.3 Software management

This course shall comprise two main areas and shall take place at the Contractor's works before equipment is delivered to site.

I). A formal course on the software detailing the various modules used and their interaction. The course shall broadly cover the following topics

- i. SAS software
- ii. Relays software.
- iii. Communication software

II). Hand-on-training on editing the database (to incorporate extensions to the power networks, inclusion of additional analogue/digital signals from existing equipment, etc.) and generating new logs, alphanumeric displays, etc.

It is envisaged that the software management courses shall extend for a period of approximately six weeks.

4.13.4 Installation and commissioning techniques

A) The Employer's staff will be present during the installation and commissioning period and it is essential that they be fully involved in any on-site corrections or modifications to hardware and software equipment.

It is envisaged that it will be necessary for the Contractor to run installation and commissioning techniques courses each of approximately one week in duration at site for the training of the Employer's staff.

B) Proposals for training and Manning

For each course recommended the following information shall be provided:

- I. Course name and identification.
- II. Short description of the curriculum.
- III. Level of competency required for each course.
- IV. Date and duration.

V. Maximum number of staff that can attend.

VI. Location.

VII. Other important information.

The times at which the various training courses will take place shall be stated, and fully documented notes shall be available to the Employer not later than two months before the commencement of the course.

All training course notes and documentation shall be in the English language.

An estimate of the total number of the Employer's staff required to run, operate and service the works covered by this Specification shall be given if this is different to the numbers specified.

The prices of the training courses shall be detailed in full such that additions or deletions to personnel or courses can be calculated by the Employer without necessarily having to contact the Contractor. This is particularly important for the 'Software management' courses where prices for formal course days and practical course days shall be individually detailed. The cost of training arranged at a location slected by AEGCL shall be within the scope of the contractor. The necessary cost of travel and accommodation of training faculty shall be borne by contractor.The cost of Travel and accommodation of AEGCL official to contractor facility for training will be in AEGCL scope. However, the contractor shall make necessary arrangement for accommodation.

4.14 Erection at Site and Accommodation

The Contractor shall provide, at his own cost and expense, all labour, plant and material necessary for unloading and erection at the Site and shall be entirely responsible for its efficient and correct operation.

The Contractor shall be responsible for arranging and providing all living accommodation services and amenities required by his employees. He shall also provide suitable office accommodation at each substation site for the sole use by AEGCL.

4.15 Site Construction Supplies

The Contractor shall provide at his own cost and expense, any site supplies of electrical energy, water and any other requirements which he may require for site operation.

All wiring and pipeing etc. for such tackle and for lighting from the point of supply shall be provided by the Contractor and all such installations shall comply with all appropriate statutory regulations to which the Employer is subject.

Wiring shall be of the best quality double insulated flexible cable, suitably fixed, protected and maintained. All necessary precautions shall be taken to ensure the safety of every person employed or working on the Site and this shall include routine inspection of all temporary installations and portable equipment.

The authorized representative of AEGCL may require the disconnection or alteration of any parts which he may consider unsafe.

As soon as any part or the whole of the Contractor’s installation is no longer required for the carrying out of the works, the Contractor shall disconnect and remove the same to the satisfaction of the authorised representative of AEGCL.

The contractor shall be responsible for arranging construction water at his own cost.

Under no circumstances AEGCL shall arrange water for construction activities.

4.16 Supervision and Checking of Work on Site

All work on site included in the Contract scope of works shall be supervised by a sufficient number of qualified representatives of the Contractor.

Before putting any plant or apparatus into operation the Contractor shall satisfy himself as to the correctness of all connections between the plant and apparatus supplied under this and other contracts. The Contractor shall advise the authorized representative of AEGCL in writing, giving the period of notice as specified in the General Conditions of Contract, when the plant or apparatus is ready for inspection or energization.

4.17 Responsibility for the Running of Plant by Contractor

Until each Section of the Contract Works has been taken over or deemed to have been taken over under the Conditions of Contract, the Contractor shall be entirely responsible for the Contract Works, whether under construction, during tests, or in use for the Employer’s service. The Contractor shall instruct the Employer’s operating staff in the recommended method of operation of the plant supplied. Such instruction shall commence prior to the commissioning of the plant and shall be followed by practical instruction for a period of up to three months for GIS after the plant is taken over by the Employer. During this specified period the Contractor shall provide an engineer, on each site that is taken over, to assist with operation of the plant and to provide on-site training of the Employer’s operating staff. The training schedule and programme for each substation shall be submitted to the authorised representative of AEGCL for approval, three months prior to the substation’s planned completion date. In the event of any emergency situation arising out of failure/outage of any parts of the GIS, the contractor shall be obliged to provide service of their competent personnel for rectification/repair of the problem within 72(Seventy-Two) hours. The contactor shall be under the obligation of this stipulation for a period of 3 (three) years with effect from date of submission of the extended guarantee. Any work which may be necessary for the Contractor to carry out in pursuance of his obligations under the Conditions of Contract shall be carried out with the minimum of interference to the normal operation of the substation. Work on the Site shall be carried out at such time and during such hours as AEGCL may require.

4.18 Compliance with Regulations

All apparatus and material supplied, and all work carried out shall comply in all respects with such of the requirements of all Regulations and Acts in force in the country of the Employer as are applicable to the Contract Works and with any other applicable regulations to which the Employer is subject.

The Contractor shall fully inform himself of the requirements of the local Laws, Regulations and rules in-force in the State of Assam, especially with respect to local employment laws, licensing requirements, electrical safety rules and regulations, building regulations and planning procedures.

The Contractor shall be responsible for applying for all necessary licenses; including Electrical Contractors License, Workman’s Permits and Certificates of Competency for Supervisors, and local government approvals required for the contract works and for the payment of all necessary fees associated with such licenses and approvals.

Correspondence with the Electrical Inspector shall be conducted through the Authorised representative of AEGCL, but the Contractor shall provide all necessary information, regarding the contract works, as may be required by the Electrical Inspector. Additionally, the Contractor shall also follow the minimum regulations on safety, employee's welfare, industry etc. as stipulated under the relevant Clause of this section.

4.19 Maintenance and Clearing of Site

The placing of materials and plant near the erection site prior to their being erected and installed shall be done in a neat, tidy and safe manner. The Contractor shall at his own expense keep the site area allocated to him and also the erection area of the Contract Works reasonably clean and shall remove all waste material as it accumulates and as directed by AEGCL from time to time.

4.20 Protection of Monuments and Reference Points

The Contractor shall ensure that any finds such as relics, antiques, coins, fossils, etc. which he may come across during the course of performance of his works either during excavation or elsewhere, are properly protected and handed over to the Employer. Similarly, the Contractor shall ensure that the bench marks, reference points, etc. which are marked either with the help of Employer or by the Employer shall not be disturbed in any way during the performance of his works. If any work is to be performed which disturbs such reference points, the same shall be done only after these are transferred to other suitable locations under the direction of the Employer. The Contractor shall provide all necessary materials and assistance for such relocation of reference points etc.

4.21 Foreign Personnel

If necessary, for the execution of the works, the Contractor shall bring foreign supervisors for the execution of the Contract at his own cost. The Contractor shall submit to the Employer data on all personnel he proposes to bring into India for the performance of the works under the Contract, at least Sixty (60) days prior to their arrival in India. Such data shall include the name of each person, his present address, his assignment and responsibility in connection with the works, and a short resume of his qualifications and experience etc. in relation to the work to be performed by him.

Any person unsuitable and unacceptable to the Employer, shall not be brought to India. Any person brought to India and found unsuitable or unacceptable to the Employer shall be immediately removed from Site and repatriated. If found necessary, he may be replaced by other personnel acceptable to the Employer.

No person brought to India by the Contractor for the works shall be repatriated without the consent of the Employer in writing, based on a written request from the Supplier for such repatriation giving reasons for such an action to the Employer. The Employer may give permission for such repatriation provided the Employer is satisfied that the progress of work will not suffer due to such repatriation. The cost of passports, visas and all other travel expenses to and from India, shall be to the Contractor's account. The Employer will not provide any residential accommodation and/or furniture for any of the Contractors personnel including foreign personnel. Contractor shall make his own arrangements for such facilities. The Contractor and his expatriate personnel shall respect all Indian Acts, Laws, Rules and Regulations and shall not in any way, interfere with Indian political and religious affairs and shall conform to any other rules and regulations which the Government of India, and the Employer may establish on them. The Contractor's expatriate personnel shall work and live in close co-operation and co-ordination with their co-workers and the community and shall not engage themselves in any other employment either part-time or full-time nor shall they take part in any local politics. The Employer shall assist the Contractor, to the extent possible, in obtaining necessary certificates and other information needed by the Government agencies.

CHAPTER: 5 LAND DEVELOPMENT AND ASSOCIATED CIVIL WORKS

Applicable Codes and Specifications

The following codes and standards are included in this section, as part of these specifications. However, respective IS codes (or latest) for the works not mentioned here shall also be applicable for those particular items of work.

IS:110	Specification for Ready mixed paint, brushing, grey filler, for enamels for use over primers.
IS:280	Specification for mild steel wire for general engineering purposes
IS:304	Specification for High Tensile Brass Ingots and Castings
IS:337	Specification for Varnish, finishing interior
IS:348	Specification for French polish
IS:383	Specification for coarse and fine aggregates from natural sources for concrete
IS:412	Specification for Expanded metal steel sheets for general purposes
IS:419	Specification for putty for use on window frames
IS:428	Washable Distemper-specification
IS:459	Indian standard unreinforced corrugated and semi-corrugated asbestos cement sheets- Specification
IS:702	Specification for industrial bitumen
IS:710	Specification for marine plywood
IS:712	Specification for building limes
IS:730	Specification for hook bolts for corrugated sheet roofing
IS:733	Specification for Wrought aluminium and aluminium alloys, bars, rods and sections (for general engineering purposes)
IS:15622	Specification for Pressed Ceramic Tiles
IS:1003	Specification for timber panelled and glazed shutters (Parts 1 & 2)
IS:1038	Specification for steel doors, windows and ventilators
IS:1077	Common burnt clay building bricks – Specification
IS:1081	Code of practice for fixing and glazing of metal (steel & aluminium) doors, windows and ventilators
IS:1124	Method of test for determination of water absorption, apparent specific gravity and porosity of natural building stones.
IS:1237	Specification for cement concrete flooring tiles
IS:1322	Specification for Bitumen felts for water proofing and damp proofing
IS:1346	Code of practice for water proofing of roofs with bitumen felts
IS:1361	Specification for steel windows for industrial buildings
IS:1397	Specification for kraft paper
IS:1443	Code of practice for laying and finishing of cement concrete flooring tiles
IS:1477	Code of practice for painting of ferrous metals in buildings (Parts1 & 2)
IS:1542	Specification for sand for plaster
IS:1580	Specification for bituminous compounds for water-proofing and caulking purposes
IS:1597	Code of practice for construction of stone masonry : Part 1 Rubble stone masonry
IS:1659	Specification for block boards
IS:1661	Code of practice for application of cement and cement-lime plaster finishes
IS:1834	Specification for hot applied sealing compound for joints in concrete

IS:1838	Specification for preformed fillers for expansion joint in pavements and structures (non- extruding and resilient type) : Part 1 Bitumen impregnated fibre
IS:1948	Specification for aluminium doors, windows and ventilators
IS:1949	Specification for aluminium windows for industrial buildings
IS:2074	Ready mixed paint, air drying, red oxide- zinc chrome, priming – Specification
IS:2098	Specification for Asbestos cement building boards
IS:2114	Code of practice for laying in-situ terrazzo floor finish
IS:2116	Specification for sand for masonry mortars
IS:2185	Specification for concrete masonry units (Parts 1,2 & 3)
IS:2202	Specification for wooden flush door shutters (Solid core type) : Parts 1 & 2
IS:2212	Code of practice for brickwork
IS:2250	Code of practice for preparation and use of masonry mortars
IS:2338	Code of practice for finishing of wood and wood based materials (Parts 1 & 2)
IS:2339	Specification for Aluminium paint for general purposes, in dual container
IS:2395	Code of practice for painting concrete, masonry and plaster surfaces (Parts 1 & 2)
IS:2402	Code of practice for external rendered finishes
IS:2571	Code of practice for laying in-situ cement concrete flooring
IS:2572	Code of practice for construction of hollow concrete block masonry
IS:2645	Integral cement waterproofing compounds for cement mortar and concrete – Specification
IS:2690	Specification for burnt clay flat terracing tiles : Part 1 Machine made
IS:2691	Specification for burnt clay facing bricks
IS:2750	Specification for steel scaffoldings
IS:2835	Flat transparent sheet glass
IS:2932	Enamel, synthetic, exterior (a) undercoating, (b)finishing – Specification
IS:3007	Code of practice for laying of asbestos cement sheets - corrugated and (Part 1 & 2) semi-corrugated sheets
IS:3036	Code of practice for laying lime concrete for a water-proofed roof finish
IS:3067	Code of practice of general design details and preparatory work for damp-proofing and water- proofing of buildings.
IS:3068	Specification for broken brick (burnt clay) coarse aggregates for use in lime concrete
IS:3384	Specification for bitumen primer for use in water-proofing and damp-proofing
IS:3461	Specification for PVC-asbestos floor tiles
IS:3462	Specification for unbacked flexible PVC flooring
IS:3495	Method of test for burnt clay building bricks: Part 1 to 4
IS:3536	Ready mixed paint, brushing, wood primer, pink – Specification
IS:3564	Hydraulically regulated Door closers specification
IS: 3614 (Part – 1)	Specification for fire checks doors : Part –I Plate metal covered and rolling type
IS: 3614 (Part	Specification for metallic and non-metallic fire check doors : Resistance

– 2)	test and performance criteria
IS:3696	Safety code of scaffolds and ladders (Parts 1 & 2)
IS:4020	Door shutter - Methods of test
IS:4021	Specification for timber door, window and ventilator frames
IS:4351	Steel door frames – Specification
IS:4443	Code of practice for use of resin type chemical resistant mortars
IS:4457	Specification for ceramic unglazed vitreous acid resisting tile
IS:4631	Code of practice for laying epoxy resin floor toppings
IS:4832	Specification for chemical resistant mortars (Part II)
IS:4860	Specification for acid resistant bricks
IS:4948	Specification for welded steel wire fabric for general use
IS:5318	Code of practice for laying of flexible PVC sheet and tile flooring
IS:5410	Cement paint- Specification
IS:5411	Specification for plastic emulsion paint (Parts 1 & 2)
IS:5437	Figured rolled and wired glass
IS:5491	Code of practice for laying of in-situ granolithic concrete floor topping
IS:6041	Code of practice for construction of autoclaved cellular concrete block masonry
IS:6042	Code of practice for construction of light weight concrete block masonry
IS:6248	Specification for metal rolling shutters and rolling grills
IS:7193	Specification for glass fibre base bitumen felts
IS:7452	Specification for hot rolled steel sections for doors, windows and ventilators
IS:8042	Specification for white Portland cement
IS:8543	Methods of testing plastics
IS:8869	Specification for washers for corrugated sheet roofing
IS:9197	Specification for epoxy resin, hardeners and epoxy resin composites for floor topping
IS:9862	Specification for ready mixed paint, brushing, bituminous, black, lead-free, acid, alkali, water and chlorine resisting
IS:12200	Code of practice for provision of water stops at transverse contraction joints in masonry and concrete dams – code of practice
BS : 476 (Part – 20)	Methods for determination of the fire resistance of elements of construction (General Principles)
BS : 476 (Part – 21)	Methods for determination of the fire resistance of load bearing elements of construction
BS : 476 (Part – 22)	Methods for determination of the fire resistance of Non-load bearing elements of construction
Part – IV Fire Protection	National Building code of India
IS : 383	Specification for coarse and fine aggregates from natural sources for concrete
IS : 432	Specification for mild steel and medium tensile steel bars and hard drawn steel wire for concrete reinforcement
IS : 456	Code of Practice for plain and reinforced concrete – Specification
IS : 458	Precast concrete Pipes (with and without reinforcement).
IS : 516	Methods of tests for strength of concrete
IS : 554	Dimensions for pipe threads where pressure- Tight joints are made on the threads – Dimension, Tolerance and designation

IS : 774	Specification for Flushing Cisterns for water closets and urinals (other than Plastic cistern)
IS : 775	Specification for Cast iron brackets and supports for wash basins and sinks.
IS : 781	Sand-cast brass screw-down bib taps and stop taps for water services
IS : 783	Code of practice for laying of concrete pipes.
IS : 1068	Electroplated coatings of Nickel plus chromium and copper plus nickel plus chromium
IS : 1077	Common burnt clay building bricks- Specification
IS : 1786	Specification for high strength deformed steel bars and wires for concrete reinforcement.
IS : 1239	Mild steel tubes ,Tubular and other wrought steel fittings – Specification
IS : 1536	Centrifugally cast (spun) iron pressure pipes for water, gas and sewage – Specification
IS : 1703	Water fittings Copper Alloy float valves (horizontal plunger type) – Specification
IS : 1726	Specification for Cast iron manhole covers and frames
IS : 1729	Cast Iron/ Ductile iron drainage pipes and pipe fittings for over ground non-pressure pipeline socket and spigot series
IS : 1742	Code of practice for buildings drainage
IS : 2116	Specification for sand for masonry mortars
IS : 2212	Code of practice for brickwork
IS : 2250	Code of practice for preparation and use of masonry mortars
IS : 2326	Specification for Automatic flushing cisterns for urinals (other than plastic cisterns)
IS : 2470	Code of practice for installation of septic tanks (Parts I & II)
IS : 2556	Vitreous sanitary appliances (Part I to Part XV)
IS : 2963	Specification for copper alloy waste fittings for wash basins and sinks
IS : 3006	Specification for chemically resistant glazed stoneware pipes and fittings.
IS : 3311	Specification for Waste plug and its accessories for sinks and wash basins
IS : 5455	Specification for cast iron steps for manholes
IS : 4127	Code of Practice for laying of glazed stoneware pipes
IS : 3495	Methods of tests of burnt clay building bricks
IS : 4111	Code of practice for ancillary structures in sewerage system
IS : 5382	Specification for rubber sealing rings for gas mains, water mains and sewers
IS : 5329	Code of practice for sanitary pipe work above ground for buildings
IS : 5434	Specification for Non-ferrous alloy bottle traps for marine use

5.1 GENERAL

The intent of this technical specification covers the following:

All civil works shall be carried out as per drawings/design provided by the Employer/Contractor and as per these specifications provided by the Employer. In case any item is not covered under specification then the same shall be carried out as applicable Standards and Codes as per employers requirement. Any item for which specification is not provided herein and is not covered under standard specification shall be executed as per manufacturer guidelines. All materials shall be of best quality conforming to relevant Indian Standards and Codes.

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

All materials including cement, reinforcement steel and structural steel, etc shall be arranged by the Contractor. All testing required shall be arranged by the contractor at his own cost. The Contractor shall execute the work as per field quality plan (FQP) attached with this document.

The bidder shall fully apprise himself of the prevailing conditions at the proposed site. Climatic conditions including monsoon patterns local conditions and site-specific parameters, soil parameters, availability of construction material and shall include for all such conditions and contingent measures in the bid, including those which may not have been specifically brought out in the specifications.

The scope shall generally cover switch yard structures, including gantries and equipment support structures and their foundations, cable trenches along with covers, cable trench crossings of road and rails, sump pits, marshalling box/control cubicle foundations, switch yard levelling, site clearance, soil investigation, roads, drains, fencing, gravel filling, transformer / reactor foundations, firewalls, control room building, other auxiliary buildings, potable water supply, street light etc. Any other items not specifically mentioned here but required for the commissioning of switch yard/substation shall be deemed to be included in the scope of this Specification. The scope shall further cover design, construction for all civil works at each substation. All civil works shall also satisfy the General Technical Clauses specified in other sections of this specification and as detailed below.

Excavation, de watering, carriage of excavated earth, plain cement concrete (PCC), casting of reinforced cement concrete (RCC) foundations, super-structures for switch yard structures, equipment supports, their control cubicles, bus post supports, lighting poles and panels, brick and stone masonry, cable trenches, pipe trenches with necessary pre cast RCC removable covers, with lifting facility and sump pits, cable supports and their embodiment in cable trenches and cable trench crossings road or rail track with backfilling complete as per drawings approved by the EMPLOYER, shall be carried out by the contractor. The cable trenches inside the control room shall be provided with MS chequered plate with angle stiffeners at the bottom for mechanical strength and painting there of as per the standard practice.

5.2 SOIL INVESTIGATION

The Contractor shall use the recommendations made in the soil investigation report provided by the Employer with this bid document for reference purpose only.

a) The Contractor shall perform a detailed soil investigation to arrive at sufficiently accurate general as well as specific information abou t the soil profile/strata and the necessary soil parameters of the site in order that the foundations of the various structures can be designed and constructed safely and rationally. Foundation systems adopted by the contractor shall ensure that relative settlement shall be as per provision in IS 1904 and any latest IS and other Indian Standards.

b) This Specification covers all the work required for detailed soil investigation and preparation of a detailed report. The work shall include mobilisation of necessary equipment, provision of necessary engineering supervision and Geotechnical Expert personnel , skilled and unskilled labour etc., as required to carry out field investigation and tests, laboratory tests, analysis and interpretation of data and results, preparation of detailed soil report including specific recommendations for the type of foundations and the safe bearing capacity for different sizes of foundations at different founding strata for the various structures of the substation. The Contractor shall make his own arrangements for locating the coordinates and various test positions in field and also for determining the reduced level of these locations with respect to the benchmark. All the test is to be carried out before the AEGCL officials or before any agency engaged by AEGCL. Prior intimation in this effect has to be given to AEGCL.

c) A report to the effect will be submitted by the Contractor for AEGCL specific approval giving details regarding his data for Civil structures design.

d) Any variation in soil data provided with bid document shall not constitute a valid reason for any additional cost and shall not affect the terms and condition of the Contract. Nothing extra whatsoever shall be paid to the Contractor on account of any variation in subsoil properties /or conditions. Tests must be conducted under all the critical locations i.e. GIS Building, Control room building, autotransformer, lightning mast, 400 kV/220 kV/132 kV column location, auxiliary buildings etc. However, some of the soil parameters given below for substations have to be determined and submitted to authorized representative of AEGCL.

   i. Dry density
   ii. Bulk density
   iii. Angle of internal friction/cohesion
   iv. Specific gravity
   v. Natural moisture content.

e) Bore holes

Drilling of a specified number of bore holes of 150 mm dia. in accordance with the provisions of IS 1892 at approved locations to specified depths or to refusal whichever occurs earlier. (By refusal it shall mean that a standard penetration blow count (N) of 100 is recorded for 30 cm penetration). Nos of bore holes shall be executed as per employer approval.

Performing Standard Penetration Tests at 1.5 m intervals in the bore hole starting from 0.5 m below ground onwards and at every change of stratum. The disturbed samples from the standard penetrometer shall also be collected for necessary tests.

Collecting undisturbed samples of 100/75 mm diameter 450 mm long from the bore holes at intervals of 2.5 m and every change of stratum starting from 1.0 m below ground level onwards. The depth of Water Table shall be recorded in each bore hole.

All samples, both disturbed and undisturbed, shall be identified properly with the bore hole number and depth from which they have been taken. The sample shall be sealed at both ends of the sampling tubes with wax immediately after the sampling and shall be packed properly and transported to the Contractor`s laboratory without any damage or loss but not limited to.

The logging of the bore holes shall be compiled immediately after the boring is completed and a copy of the bore log shall be handed over to AEGCL duly signed by representative of employer.

f) Dynamic cone penetration test

Two Dynamic cone penetration tests under the locations of auto transformers shall be carried out with the circulation of bentonic slurry at specified location and a continuous record of penetration resistance (NG) up to 15 metre from natural ground level or refusal, shall be maintained by the Contractor.
Dynamic cone penetration tests are conducted to correlate engineering properties such as stratification density, bearing capacity, settlement, etc., of soils which are primarily cohesive in nature. The tests shall be conducted by driving a standard size cone attached loosely or screwed to a string of drill rods. The specification for the equipment and accessories required for performing this test, test procedure, field observations and reporting of results shall confirm to IS 4968-part 11 latest revision. The driving system shall comprise of 65 kg weight having a free fall of 75 cm. The cone size shall be 65 mm diameter, and provided with vents for continuous flow of bentonite slurry through the cone and rods in order to avoid friction between the rods and soil. The location for tests shall be as directed by AEGCL. On completion of the test, the results shall be presented as a continuous record as the number of blows required for every 300 mm penetration of the cone into the soil.

g) Trial pits

Trial pits shall be made at two locations as approved by AEGCL. The trial pits shall be 2 meters square in size extending to (four) meters depth or as specified by AEGCL. Undisturbed samples shall be taken from the trial pits as per the direction of AEGCL.

h) Field California Bearing Ratio test

This test shall be carried out to obtain the properties of soil required for the construction of roads. The equipment and accessories required for carrying out the test, test procedure, recording of observations and presentation of results shall confirm to IS 2770 part **XXXI.** The test locations of CBR test shall be on the road loc-ations as per GA drawing. These tests shall be performed on remoulded and undisturbed, soaked and un soaked samples.

i) Electrical resistivity test.

This test shall be conducted to determine the electrical resistivity of soil required for designing safety grounding system for the entire station area. The specifications for the equipment and other accessories required for performing electrical resistivity test, the test procedure, and reporting of field observations shall confirm to IS 3043. The test shall be conducted using Wenner's four electrode method as specified in IS 1892, Appendix-B2. Unless otherwise specified at each test location, the test shall be conducted along two perpendicular lines parallel to the coordinate axis.
The following formula shall be used for measuring soil resisitivity :

$$P = 2 \pi a R$$

Where a = Interelectrode spacing = 50M

R = Earth resistance measured in Ohms

P = Soil Resistivity in Ohm- m

The soil resistivity values shall be submitted duly marked on the route map and also in the form of statement. The quoted rates for detailed survey/ check survey work shall be inclusive of cost of measuring soil resistivity values along the proposed route and the contractor will not be paid separately for this work.

j) Plate load test

Plate load test shall be conducted to determine the bearing capacity and load/ settlement characteristics of soil at shallow depths by loading a plane and level steel plate kept at the desired depth and measuring the settlement under different loads, until a desired settlement takes place or failure occurs. The specification for the equipment and accessories required for conducting the test, the test procedure, field observations and reporting of results shall conform to IS 1888. Nos of Plate load test shall be conducted as per employer requirement. The location and depth of the test shall be given by the Contractor and approved by AEGCL. Undisturbed tube samples shall be collected at 1.0 m and 2.5 m depths from the natural ground level for carrying out laboratory tests.

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

If the ground water table is at a depth higher than the specified test depth, the ground water table shall be lowered and maintained at the test depth for the entire duration of the test. Dewatering shall be at Contractor's cost.

Unless otherwise specified the reaction method of loading shall be adopted. Settlement shall be recorded from dial gauges placed at four diametrically opposite ends of the test plate. The test plate shall be 600 x 600 mm size and at least 25mm thick. The bottom of the pit shall be levelled before placing the plate in position for conducting the test.

A seating load of 70 gm/sq.cm shall be applied and after the dial gauge readings are stabilized, the load shall be released, and the initial readings of the dial gauges recorded after they indicate constant reading. The load shall be increased in stages. These stages shall be 20, 40, 70, 100, 150, 200, 250, 300, 400. 500, 600 and 800 KN per sqm or as directed by AEGCL. Under each loading stage, record of time versus settlement shall be kept as specified in IS 1888**.**

The load shall be maintained for a minimum duration of one hour or till the settlement rate reduces to 0.02 mm/m. whichever is later. No extrapolation of settlement rate from periods less than one hour shall be permitted.

Loading shall be carried out in stages as specified above till one of the following conditions occurs:

i. Failure of the soil under the plate i.e. the settlement of the plate at constant load becomes progressive and reaches a value of 40 mm or more.

ii. Total settlement of the plate is more than 4Omm.

iii. Load intensity of 800 kN/sq.m is reached without failure of the soil.

Backfilling of the pit shall be carried out as per the directions of AEGCL. Unless otherwise specified the excavated soil shall be used for this purpose. The quoted rates shall include backfilling.

Dial gauge readings for settlement shall generally be taken at 1, 2, 4, 6, 9, 16, 25, 60, 90 and 120 minutes from the commencement of each stage of loading. Thereafter the readings shall be taken at hourly intervals upto a further four hours and at two hours intervals thereafter for another six hours.

k) Water sample

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

l) Laboratory Test

The laboratory tests shall be carried out progressively during the field work after a sufficient number of samples have reached the laboratory, in order that the test results of the initial bore holes can be made use of in planning the later stages of the field investigation and quantum of laboratory tests.

All samples brought from field, whether disturbed or undisturbed shall be extracted/prepared and examined by competent technical personnel, and the tests shall be carried out as per the procedures laid out in the latest edition of the relevant IS Codes and Standards.

The following laboratory tests shall be carried out:

i. Visual and engineering classification.

ii. Liquid limit, plastic limit and and shrinkage limit.

iii. Optimum moisture content, bulk density, dry density and specific gravity.

iv. Grain size distribution.

v. Unconfined compression test.

vi. Unconsolidated undrained test.

vii. Swell pressure and free swell index determination.

viii. California bearing ratio.

ix. Consolidated undrained test.

x. Consolidated drained test.

xi. Chemical tests on soil and water to determine the carbonates, sulphates, nitrates, chlorides, Ph value, and organic or inorganic matter and any other chemicals harmful to the concrete foundation.

Test results and reports

The Contractor shall submit the detailed report in four (4) 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. Initially the report shall be submitted by the Contractor in draft form and after the draft report is approved, the final report in eight (8) copies shall be submitted.

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

- A plan showing the locations of an exploration work i.e. bore holes, dynamic cone penetration tests, trial pits, plate load test, etc.
- Bore logs: Bore logs of each bore holes clearly identifying the stratification and type of soil stratum with depth up to the refusal. The values of Standard Penetration Test (SPT) at the depths where the tests were conducted on the samples collected shall be clearly shown against that particular stratum.
- Test results of field and laboratory 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.

- **Recommendation** 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 AEGCL. The observations and recommendations shall include but not be 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 shall be given.
- 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 for the recommendations.
- Recommendations regarding slope of excavations and dewatering schemes, if required.
- Comments on the chemical nature of soil and ground water with due regard to protective measures.
- If expansive soil is met with, recommendation on removal or retainment of the same under the structure/road etc. shall be given. In the latter case detailed specification of any special treatment required including specification for materials to be used, construction method and equipment to be deployed etc. shall be furnished.
- Recommendations for additional investigation beyond the scope of the present work, if Contractor considers such investigation necessary.

5.3 STANDARDS, DESIGN AND DRAWINGS

a) All Civil works shall be carried out as per applicable Indian Laws, latest revision of /International Standards and Codes. All materials shall be of best quality confirming to relevant Indian Standards and Codes. Civil works shall be designed to the required service conditions and /or loads as specified elsewhere in this Specification or implied as per National and International Standards. In case of any conflict between I.S. Code and the Procedures specified herein, the later shall prevail.

b) All foundations/RCC Design shall be of reinforced cement concrete and shall be as per requirementds of earthquake and wind for zone-V region of IS. The design and construction of RCC structures shall be carried out as per IS 456 and minimum grade of concrete shall be M20 corresponding to 1:1.5:3 (M20) nominal mix ratio with 12-20 mm coarse aggregate. Higher grades of concrete than specified above may be used at the discretion of the Bidder without any financial implication to the owner. Work covered under this clause of the specification comprises the construction of foundations and other RCC constructions for switchyard structures, equipment support, trenches, drains, jacking pad, pulling block, control cubicles, bus supports, Auto transformer/power transformer/reactors, marshalling kiosks, auxiliary equipment’s and system buildings, tank or for any other equipment or service and any other foundation required to complete the work. Also applicable to other RCC constructions. If the site is sloping, the foundation height will be adjusted to maintain the exact level of the top of structures to compensate such slopes. Minimum 75 mm thick lean concrete shall be provided below underground structures, foundations, trenches etc. to provide a base for construction. 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 special footing or pile foundations as may be required based on soil/sub-soil conditions and superimposed loads shall be provided. The switchyard foundations plinths and building plinths shall be minimum 900mm and 1200mm above finished ground level respectivelyAdmixtures in concrete shall confirm to IS: 9103. The water proofing cement additives shall confirm to IS: 2645. Concrete Admixtures/Additives shall be approved by the owner. Limit state method of design shall be adopted unless stated otherwise in the Specification. For design and construction of steel-concrete composite beams IS 11384 shall be followed. For detailing of reinforcement IS 2502 and SP: 34 shall be followed. Two layers of reinforcement (on inner and outer face) shall be provided for wall and slab sections having thickness of 125 mm and above. Clear cover to reinforcement towards the earth face shall be minimum 50 mm. RCC water retaining structures such as storage tanks, cooling water basin etc. shall be designed as uncracked sections in accordance with IS 3370 (Part 1 to IV) by working stress method and shall also be tested for water tightness at full water level. However, water channels shall be designed as cracked sections with limited steel stresses as per IS 3370 (Part 1 to IV) by working stress method. 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 produce the maximum stresses in the foundation or the foundation component, and as per the relevant IS Codes of foundation design. The design calculations shall be submitted by the bidder showing complete details of piles/pile groups proposed to be used. All foundations shall rest below virgin ground level and the minimum depth of foundation below the virgin ground level shall be maintained. Design shall consider any sub-soil water pressure that may be encountered. 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 or harmful to the concrete foundations. RCC columns shall be provided with rigid connection at the base. All building 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 as stated in relevant IS Codes or as stipulated elsewhere in the Specifications. Earth pressure for all underground structures shall be calculated using coefficient of earth pressure at rest, coefficient 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, and substructures of any underground hollow enclosure etc., to allow for vehicular traffic in the vicinity of the structure.

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.

Pile Foundation shall be done for GIS buildings, Control room building, Transformer foundations and Reactor foundations, Fire protection wall and any other heavily loaded structure. The quotated rate for these structures shall be inclusive of pile foundation.

Any detail specification for carrying out pile foundation works which is not mentioned in this chapter shall be as per relevant IS codes and Chapter 35 of this bid document.

The foundation of the transformer and circuit breaker shall be of block type foundation. Minimum reinforcement shall be governed by IS:2974 and IS:456.

The tower and equipment foundations shall be checked for a factor of safety of 2.2 for normal condition and 1.65 for short circuit condition against sliding, overturning and pullout. The same factor shall be used as partial safety factor overloads in limit state design also.

All underground concrete structures such as basements, pump houses, water retaining structures etc. shall have water proofing cement additive conforming to IS 9103. In addition, the limit on permeability as given in IS 2645 shall also be met. The concrete surface of these structures in contact with earth shall also be provided with two coats of bituminous painting for water /damp proofing.

In case of water leakage in the above structures, leakage repair shall be achieved by the injection method.

The following conditions shall be considered for the design of water tanks, pump houses, channels, sumps, trenches and other underground concrete structures such as basements etc.

Full water pressure from inside and no earth pressure, ground water pressure and surcharge pressure from outside (applicable only to structures which are liable to be filled 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 slabs of any underground enclosures shall be designed for empty condition during construction and maintenance stages with maximum ground water table (GWT).

Base slab of underground enclosures such as water storage tank shall also be designed for the condition of different combination of pump sumps being empty during maintenance stages with maximum GWT. Intermediate dividing piers of such enclosures shall be designed considering water in one pump sump only and the other pump sump being empty for maintenance.

c) Machine Foundations

All machine foundations shall be designed in accordance to the provisions of the relevant parts of the latest revisions of IS 2974, IS 456 and IS 2911.The provisions of DIN 4O24 (latest) shall also be followed. All block foundations resting on soil or piles shall be designed using the elastic half space theory.

The mass of the RCC block shall not be less than three times the mass of the machine. Dynamic analysis shall be carried out to calculate natural frequencies in all the modes including coupled modes, and to calculate vibration amplitudes. Frequency and amplitude criteria as laid down by the relevant IS codes and/or machine manufacturers, shall be satisfied. Minimum reinforcement shall be governed by IS 2974 and IS 456.

For the foundations supporting minor equipment weighing less than one tonne, or if the mass of the rotating parts is less than one-hundredth of the mass of the foundation, no dynamic analysis is necessary. However, if such minor equipment is to be supported on building structures, floors etc. suitable vibration isolation shall be provided by means of springs, neoprene pads etc. and such vibration isolation system shall be designed suitably.

d) Other Foundations

All foundations shall be designed in accordance with the provisions of the relevant parts of latest revisions of IS 2911 and IS 456. Type of foundation system i.e. isolated footing, raft or piling shall be decided based on the load intensity and soil strata. A minimum TWO piles shall be provided in any pile group. Gantry and tower foundations shall be designed for an additional factor of safety of 1.2 for normal/ broken wire conditions and for short circuit condition. Circuit breaker foundations shall be designed for impact loading and shall be strictly in accordance with the Manufacturer`s recommendations.

e) 400 KV GIS Building - Architectural Drawings are enclosed with the tender documents. Structural Drawing shall be prepared by the Contractor.

f) 220 KV GIS Building - Architectural Drawings are enclosed with the tender documents. Structural Drawing shall be prepared by the Contractor.

g) 33kV Switchgear & Control Room building– Architectural Drawings are enclosed with the tender documents. Structural Drawing shall be prepared by the Contractor.

h) Kiosk Building - Drawing to be prepared by contractor on the basis of specifications provided in the bid document.

i) Fire fighting pump house Building & Fire water Tank

j) R.E Residence - Architectural Drawings are enclosed with the tender documents. Structural Drawing shall be prepared by the Contractor.

k) Transit Camp - Architectural Drawings are enclosed with the tender documents. Structural Drawing shall be prepared by the Contractor.

l) Officers Hostel - Architectural Drawings are enclosed with the tender documents. Structural Drawing shall be prepared by the Contractor.

m) Staff hostel - Architectural Drawings are enclosed with the tender documents. Structural Drawing shall be prepared by the Contractor.

n) Security Barrack - Architectural Drawings are enclosed with the tender documents. Structural Drawing shall be prepared by the Contractor.

o) Security Booth - Architectural Drawings are enclosed with the tender documents. Structural Drawing shall be prepared by the Contractor.

p) Open Store Shed - Architectural Drawings are enclosed with the tender documents. Structural Drawing shall be prepared by the Contractor.

q) Store Building - Architectural Drawings are enclosed with the tender documents. Structural Drawing shall be prepared by the Contractor

r) Septic Tank and Soak Pit - Drawing to be prepared by contractor on the basis of specifications provided in the bid document.

s) Roads and RCC box culverts – Drawing to be prepared by contractor on the basis of specifications provided in the bid document.

t) Drains - Drawing enclosed with the bid document. Any additional drawing necesary shall be prepared by the Contractor.

u) Security fencing – Drawing enclosed with the bid document.

v) Gate - Drawing enclosed with the bid document

w) Cable trenches - Drawing enclosed with the bid document.

The drawings provided with tender documents are initial drawings and are for reference purpose only, there may be some changes in final drawing as per the site condition/eqipments/panels and the same shall be prepared by contrsctor according to site/work requirements.

5.4 SITE CLEARANCE

b) Clearing and Grubbing

The work shall consist of numbering of trees, removing and disposing of all materials such as trees, bushes, woods, shrubs, grass, stumps, rubbish, rank vegetation, roots, foreign materials, obsolete structure and foundation etc., which in the opinion of EMPLOYER are unsuitable for incorporation in the works, from within the limits and such other areas as may be specified on the drawings or directed by EMPLOYER. Clearing and grubbing shall be performed in advance of earthwork operations and in accordance with the requirements of these Specifications and includes earthfilling required for levelling of land after demolishing existing structures. During clearing and grubbing, the contractor shall take all adequate precautions against soil erosion, water pollution etc., and where required undertake additional works to that effect.

c) Setting out and making profiles

After joint survey the Contractor with AEGCL's Engineer, have to prepare a Contour Map showing the existing levels of that area in respect of the B.M. The same shall have to be submitted to the Employer for scrutiny and approval with a comparison to the Contour Map provided by the Employer with the Bid Document and citing the variations (if any). Construction of general grid, B.M, HFL pillars etc is the responsibility of the Contractor. The Contractor shall give all help in instruments, materials and personal to the Employer for checking the detailed layout and shall be solely responsible for the correctness of the layout and levels. A grid system of co-ordinates shall be established by the Contractor at the site. Reinforced concrete pillars of size 300mmX300mm shall be erected suitably at minimum of four places in the area to serve as benchmarks for the execution of the work. Each benchmark shall be protected from damage or disturbance. These benchmarks shall be connected with G.T.S. of any other permanent benchmark approved by EMPLOYER. Necessary profiles with pegs, bamboos and strings or 'Burjis' shall be made to show the correct formation levels before the work is started and the same shall be approved by EMPLOYER.

As per contour of the switchyard site, the Contractor shall have to prepare the site by earth cutting or filling as per site condition to arrive at the required F.G.L. Site levelling shall be in the scope of the Contractor. The finished ground level (FGL) of the switchyard area shall have to be fixed as approved by EMPLOYER above the highest flood level (HFL) of that area or site.

After the site has been cleared the limits of excavation shall be set out true to lines, curves, slopes, grades and sections as shown on the drawings or as directed by EMPLOYER. The Contractor at his own cost shall make the layout and levels of all structure, etc., from the general grids of the plot and benchmarks set by the Contractor and approved by the Employer.

d) Programme

The Contractor shall execute the works as per the approved schedule in accordance with the requirements of this Specification.

e) Inclement weather

As per relevant Code, during hot weather, precautions shall be taken to avoid premature stiffening of the fresh mix and to reduce water absorption and evaporation losses. During hot weather (atmospheric temperature above 40 degree C) or cold weather (atmospheric temperature at or below 5deg.C) concreting shall be done as per the procedure set out in IS 7861.

5.5 MATERIALS AND WORKMANSHIP

a) **General** –
All materials used in the works shall be new and of the best quality of their respective kinds. They shall comply with the requirements of the latest edition of any relevant Indian Standard or Code of Practice where such exist, and current at the date of tendering. All workmanship shall be of the highest standard and shall be executed by competent men skilled in their respective trades.

b) **Samples** –
In addition to the special provisions made in this specification for sampling and testing of materials by particular methods, samples of any materials and workmanship proposed to be used in the Works may be called for at any time during the Contract by EMPLOYER and shall be furnished by the Contractor without delay and at the expense of the Contractor. Samples when approved, shall be regarded as the acceptable standard, and any material or workmanship subsequently not complying with that standard shall be rejected and replaced by those of acceptable standard at the expense of the Contractor. Sample storage boxes shall be provided by the Contractor free of cost if requested by EMPLOYER.

c) **Tests** –
Whenever considered desirable by EMPLOYER, inspectors may be sent to manufacturer's premises to test materials or supervise their manufacture. Where specified or requested the Contractor shall obtain from the manufacturer and send to EMPLOYER, certificates of test, proof sheets, mill sheets, etc., showing that materials have been tested in accordance with this Specification or the relevant Indian Standard. Notwithstanding any tests which may be directed to be carried out at a manufacturer's works, EMPLOYER may carry out any tests or further tests he considers necessary or desirable after delivery of materials to the Site. The Contractor shall provide all labour, equipment and facilities necessary for carrying out the tests both in works and on site. The cost of routine tests required by IS and this Specification shall be borne by the Contractor. The cost of other tests shall be borne in accordance with the Conditions of Contract.

d) **Names of suppliers and copies of orders**-
If so required, and before ordering material of any description, the Contractor shall submit for approval the names of makers or suppliers proposed. Copies of orders shall also be submitted if so required. EMPLOYER may at any time withdraw his previously given approval to obtaining materials from any maker or supplier should such maker or supplier fail to supply materials of the specified quality or quantity in the requisite time.

e) **Rejection of materials and workmanship** –
EMPLOYER shall at any time have power to reject materials and workmanship not complying with this Specification or with the approved Drawings. Materials so rejected shall be immediately removed from site and replaced by materials of an approved standard at the expense of the Contractor. Rejected workmanship shall be broken out and replaced by work of an acceptable standard including the supply of new

materials by the Contractor, at the expense of the Contractor, and without delay.

f) Explosives and Blasting –

All rules under the Explosive Act or other local rules in force shall be fully observed. All blasting works shall be done in accordance with the stipulation contained in IS 4081. Written approval shall be obtained from EMPLOYER before explosives are used for excavating foundations in rock and EMPLOYER may impose conditions for their use. The Contractor shall be responsible for complying with local regulations concerning the use of explosives and for the safe-keeping and handling of explosives. Proper warning shall be given of all blasting operations. During operations involving the handling or use of explosives, the Contractor shall be responsible for the safety of personnel, Site Works and people or properties in the vicinity of the site. The Contractor shall make good at his own expense any damage caused by the use or mishandling of explosives.

5.6 EXCAVATION AND BACKFILL

Excavation and backfill for foundations shall be in accordance with the relevant Code. The back fill around the foundations shall be compacted according to the specification mentioned for Compaction.

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.

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 one meter in height.

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 EMPLOYER. Rocks larger than ten centimeters shall not be placed in embankment adjacent to structures.

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.

Rock excavation - The rock to be excavated shall be classified under the following categories:

i. Ordinary rock - Rock which does not require blasting, wedging or similar means for excavation is considered as ordinary rock. This may be quarried or split with crowbars or pickaxes and includes limestone, sandstone, hard laterite, hard conglomerate and reinforced cement concrete below ground level. It will also include rock which is normally hard requiring blasting when dry but can be excavated without blasting, wedging or similar means when wet. It may require light blasting for loosening materials, but this will not any way entitle the material to be classified as hard rock.

ii. Hard Rock - Any rock or boulder for the excavation of which blasting is required, for example quartzite stone, granite, basalt, reinforced concrete (reinforcement to cut through but not separated from concrete) below ground level.

iii. Hard Rock (Blasting prohibited) - This shall cover any hard rock requiring blasting as described in above but where blasting is prohibited for any reason and excavation has to be carried out by chiseling, wedging or any other approved method

Authority for classification

The classification of excavation shall be decided by EMPLOYER and his decision shall be final and binding on the Contractor. Merely the use of explosives in excavation will not be considered as a reason for higher classification unless blasting is clearly necessary in the opinion of EMPLOYER.

Excavations for foundations and other purposes

Excavations shall be of the minimum sizes necessary for the proper construction of the works, and excavations shall not be kept open for periods longer than that reasonably required to construct the works. The Contractor shall take all precautions necessary to ensure that the bottoms of excavations are protected from deterioration and that the excavations are carried out in such a manner that adjacent foundations, pipes or such like are not undermined, damaged or weakened in any way. Any excavation taken out below the proper level without approval shall be made good at the expense of the Contractor using concrete or other material as directed.

All excavated materials obtained from excavation shall remain EMPLOYER`s property. The useful portion shall be separated from the useless one and deposited in regular stacks at places indicated and as directed by EMPLOYER.

Support for excavations against collapsing

The Contractor shall be responsible for the stability of the sides of the excavations. Excavations shall be close timbered or sheeted, planked and strutted as and when necessary during the course of the work and shall ensure the safety of personnel working within them. If any slips occur, they shall, as soon as practicable, be made good in an approved manner at the expense of the Contractor. Shoring shall not be removed until the possibility of damaging the works by earth pressure has passed. No payment for shoring or timber left in shall be made.

Works shall be carried in dry condition

All excavations shall be kept free from water and the Contractor shall take whatever action is necessary to achieve this. Pumping, well pointing and other means necessary to maintain the excavations free from water shall be at the expense of the Contractor, and carried out in an approved manner.

Backfilling

As soon as possible after the permanent works are sufficiently hard and have been inspected and approved, backfill shall be placed where necessary and thoroughly consolidated in layers not exceeding two hundred (200) millimetres in depth.

On completion of structures, the earth surrounding them shall be accurately finished to the line and grade as shown on the drawings. Finished surfaces shall be free of irregularities and depressions.

The soil to be used for back filling purposes shall be from the excavated earth or from borrow pits, as directed by EMPLOYER.

Disposal of surplus

Surplus excavated material not required or not approved for fill or backfill shall be loaded and deposited either on or off site as directed. The Contractor shall not delay disposal of surplus material after receipt of instructions from EMPLOYER. The contractor shall arrange to transport the excavated earth by mechanical transport, not necessarily on Pucca roads. The soil so transported shall be stacked and levelled neatly and dressed. The location for disposal of shall be arranged by contractor at their own cost and responsibility within 5kM from the site observing necessary government law and regulation.

Compaction:

The method and equipment used to compact the fill material to a density that will give the allowable soil bearing pressure required for the foundations, roads, etc. in each layer of fill material. Each layer of earth embankment when compacted shall be as close to optimum moisture content (OMC) as practicable. Embankment material which does not contain sufficient moisture to obtain proper compaction shall be wetted. If the material contains an excess of moisture, then it shall be allowed to dry before rolling. The rolling shall begin at the edges overlaping half the width of the roller each time and progress to the center of the road or towards the building as applicable. Rolling will also be required on rockfills. No compaction shall be carried out in rainy weather.

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.

The density to which fill material shall be compacted shall be as per relevant IS and as per direction of Authorised representative 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 subgrade for the roads and embankment filling shall be compacted to minimum 95% of the Standard Proctor's density at OMC. Proctor test to be done at site in the presence of Employer.

Requirement for filling material under foundations

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.

Where compacted fill is required it shall consist of suitable sand, or other selective inorganic material, subject to approval by EMPLOYER. The filling shall be done with locally available sand. The filled in sand shall be kept immersed in water for sufficient time to ensure compaction, if so desired by EMPLOYER.

5.7 SITE PREPARATION AND EARTH FILLING

a) **Scope of Work** - The contractor shall furnish all labour, equipment and materials required for complete performance of the work in accordance with the drawings, specification and direction of EMPLOYER. The method and equipment used to compact the fill material to a density that will give the allowable soil bearing pressure required for the foundations, roads, etc. in each layer of fill material. Each layer of earth embankment when compacted shall be as close to optimum moisture content (OMC) as practicable. Embankment material which does not contain sufficient moisture to obtain proper compaction shall be wetted. If the material contains an excess of moisture, then it shall be allowed to dry before rolling. The rolling shall begin at the edges overlaping half the width of the roller each time and progress to the center of the road or towards the building as applicable. Rolling will also be required on rockfills. No compaction shall be carried out in rainy weather. 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. The density to which fill material shall be compacted shall be as per relevant IS and as per direction of Authorised representative 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 subgrade for the embankment filling shall be compacted to minimum 95% of the Standard Proctor's density at OMC. Proctor test to be done at site in the presence of Employer.

b) General Requirement - The material required for site surfacing, earthfilling, gravel filling shall be free from all types of organic materials and shall be of standard approved quality, and as directed by EMPLOYER.

The Contractor shall furnish and install the site surfacing to the lines and grades as shown in the drawing and in accordance with the requirements and direction of EMPLOYER. The soil of the entire switchyard area shall be levelled before placing the site surfacing/gravel fill material. The earthfilling where required should be done and compacted as per specifications, in layers of 200 mm. After all the structures and equipment have been erected and accepted the site shall be maintained to the lines and grades indicated in the drawing and rolled or compacted by using three ton roller with suitable water sprinkling to form a smooth and compact surface condition, which shall be matching with finished ground level of the switchyard area.

5.8 BOUNDARY WALL

The scope includes the design, engineering and construction of the boundary wall all along the property line of the EMPLOYER on each sub-station.

Construction of Boundary wall: The boundary wall shall be constructed to a height of 2.1 mtrs above finished ground level of the substation area with 5 inches wide brick masonry work with RCC (1:1.5:3) ground tie beam to be rested on the RCC pillars **(pillar to pillar distance @ 2.5mtrs)** as detailed below. Six (6) nos. Expansion Joint shall be provided at a maximum of 25 m. Reinforced barbed tape on MS frame (50X50X5 mm) and concertina coil fencing 600mm Dia 10guage with Razer edges all as per standard drawing fencing shall be provided on top of the boundary wall as detailed below.

The boundary wall shall be designed based on the soil investigation data. Salient points to be considered at the time of design:

(1) Random rubble masonry wall for retaining wall as per relevant IS code. – Minimium top width of Random Rubble Masonary shall be 600 mm.

(2) RCC (1:1.5:3) pillars to be considered : RCC pillar to pillar distance shall be maximum 5 mtrs along the boundary line. The height of the RCC pillars shall be 2.1 mtrs above finished ground level of the substation area and a minimum of 600 mm depth below the virgin (natural) soil.

Size of the RCC Pillar: Min. 250mmX250mm.
Provision of steel bar: (a) Vertical 12 mm Ø: 6 Nos. (b) Stirrup: 8 mm Ø,150 mm c/c minimum.
There shall be provision of RCC Raft at the bottom of the RCC pillar. Size of the Raft shall not be less than 900mmX900mmX200mm.
Provision of steel bar: (a) Both way top & Bottom 12 mm Ø in two layers @ 150mm c/c minimum.

(3) RCC (1:1.5:3) beam:

i) **Tie beam/Plinth beam** - Continuous RCC tie beam/plinth beam of suiable size to be rested on the RCC pillars above the finished ground level all along the boundary line.
Provision of steel bar: (a) Horizontal 12 mm Ø: 6 Nos. (b) Stirrup: 8 mm Ø, 150 mm C to C.

ii) Mid Beam - Continuous RCC mid beam of min. size 125 X 125 mm to be rested on the RCC pillars at a height of 1 m from FGL all along the boundary line.
Provision of steel bar: (a) Horizontal 10 mm Ø: 4 Nos. (b) Stirrup: 8 mm Ø, 150 mm C to C.

iii) Top Beam - Continuous RCC top beam of min. size 250 X 125 mm to be rested on the RCC pillars all along the boundary line.
Provision of steel bar: (a) Horizontal 10 mm Ø: 4 Nos. (b) Stirrup: 8 mm Ø, 150 mm C to C.

(4) Brick works: 1st Class Brick work all along the boundary wall to be provided above plinth beam. Cement sand mortar of ratio (1:4) to be provided for brick masonry works. A 50mm height of finished concrete (ratio 1:2:4) shall be provided on the top of the boundary wall.

(5) BRICK: The bricks shall be Cement Bricks or Clay Bricks for all buildings. For GIS buildings they shall be Cement Bricks or Clay Bricks or AAC Block. The bricks shall be machine moulded and shall be free from cracks and nodules of free lime. They shall have smooth rectangular faces with sharp corners and shall be of uniform colour. The bricks shall be moulded with the frog of 100mm x 40 mm and 10mm to 20mm deep on one of its flat sides. The bricks shall not break when thrown on the ground from a height of 1.2 mtrs

The size of the modular bricks shall be 190 x 90 x 90 mm.
The size of the conventional bricks shall be 250 x 125 x 75mm.
Only bricks of one standard size shall be used on one work. The following tolerance shall be permitted in the conventional size adopted in a particular work. Length +3.0mm, Width + 1.50mm, Height +1.50mm.

The crushing strength of the brick shall not be less than 17 N/mm^2. The average water absorption shall be within 13- 15% by weight. Necessary test for crushing strength and water absorption shall be carried out as per IS 3495: (Part I to Part IV) 1976.

Cement plastering works: Cement sand mortars of ratio (1:4) to be provided both the sides of the boundary wall.

Colouring: Primer and two coats of weather coats synthetic paint to be applied.
In case the boundary wall to be designed considering pile foundation, the minimum dia of the pile shall be 250mm of required length as per the design based on soil investigation. Rest of the boundary wall shall be in line with the above description.

5.9 BUILDINGS & GENERAL REQUIREMENTS

a) General

The scope includes the design, engineering and construction of 400 KV GIS Building, 220 KV GIS Building, 33kV Switchgear & Control Room building cum Administrative Building and colony quarters building as per approved drawing with the bid document. For control room and colony quarter building the tentative layout showing the facilities to be provided is indicated somewhere and also to be proposed by the bidders for better utility and aesthetic view..

b)Dimensions

An open space of one metre minimum shall be provided on the periphery of the rows of panels, and equipment generally, in order to allow easy operator movement and access as well as maintenance.

The building design shall also take into consideration the layout of the panels, switchboards, switchgear and other equipment in order to allow enough area for the future extension of switchyard depending upon the availability of substation area.

c) Design

The buildings shall be designed:

- to the requirements of the National Building Code of India. and the standards quoted therein
- for the specified climatic and loading conditions
- 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
- with a functional and economical space arrangement
- for a life expectancy of structure, systems and components not less than that of the equipment which is contained in the buildings, provided regular maintenance is carried out
- to be aesthetically pleasing. Different buildings shall show a uniformity and consistency in architectural design
- 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
- with material preventing dust accumulation
- Suitable expansion joints shall be provided in the longitudinal direction wherever necessary with provision of twin columns.
- Individual members of the building frame shall be designed for the worst combination of forces such as bending moment, axial force, shear force, torsion etc.
- Permissible stresses for different load combinations shall be taken as per relevant IS Codes.
- All cable vaults shall be located above ground level i.e. cable vaults shall not be provided as basements in the buildings. The building lighting shall be designed in accordance with the requirements of relevant section.

- The building auxiliary services such as 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 sections of this Specifications.

d) Design Loads

Building structures shall be designed for the most critical combinations of dead loads, super-imposed loads, equipment loads, crane loads, wind loads, seismic loads, and temperature loads. In addition, loads and forces developed due to differential settlement shall also be considered. Dead load shall include the weight of structures, complete finishes, fixtures and partitions and should be taken as per IS:1911 (latest revision). 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. Equipment loads shall constitute, if applicable, all load of equipments to be supported on the building frame. For crane loads an impact factor of 30% and lateral crane surge of 10% of (lifted weight plus trolley weight) shall be considered in the analysis of frame according to provisions of IS:875 (latest revision). The horizontal surge shall be 5% of the static wheel load.

For temperature loading, the total temperature variation shall be considered as two thirds of the average maximum annual variation in temperature. The average maximum annual variation in temperature for the purpose shall be taken as the difference between the mean of the daily minimum temperature during the coldest month of the year and mean of daily maximum temperature during the hottest month of the year. The structure shall be designed to withstand stresses due to 50% of the total temperature variation.

Wind loads shall be computed as per IS:875. Seismic coefficient method shall be used for the seismic analysis as per IS 1893 (latest revision), wind and seismic forces shall not be considered to act simultaneously.

Floors/slabs shall be designed to carry loads imposed by equipment, cables, piping travel of maintenance trucks and equipment and other loads associated with the building. In general, floors shall be designed for live loads as per relevant IS and cable and piping loads not less than 5 kN/ sq.m hanging from the underside. In addition, beams shall be designed for incidental point loads of 20 kN to be applied at any point along the beams. The floor loads shall be subject to the approval of EMPLOYER.

For consideration of loads on structures, IS 875 - Code of practice for structural safety of buildings shall be followed. The minimum superimposed live loads shown in Table shall be considered for the design.

Roof	150 kg / sq m. 75 kg / sq m.	for accessible roofs. for non - accessible roof.
R C C Floors.	500 kg / sq m.	for offices and minimum 1000kg/sq.m. for equipment floors or actual requirement, if higher than 1000kg/sq. m., based on equipment component weight and layout plans.
Stairs and balconies.	500 kg / m.	
Toilet Rooms.	200 kg / m.	
Chequered plate floor.	400 kg /sq. m	
Walkways.	300 kg /sq. m.	

e)Submission of data for approval

The following information shall be submitted for review and approval to EMPLOYER:

- Design criteria for structural steel and reinforced concrete design. The criteria shall comprise the codes and standards used, applicable climatic data including wind loads, earthquake factors and maximum and minimum temperatures applicable to the building locations, assumptions of dead and live loads, including equipment loads, impact factors, safety factors and other relevant information.
- Structural design calculations and drawings including those for construction and fabrication for all reinforced concrete and structural steel structures.
- Fully dimensioned floor plans, cross sections, longitudinal sections and elevations of each building. These drawings shall be drawn at a scale not less than 1:50 and shall identify the major building components.
- 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.
- Product information of building components and materials, including walls, partitions, flooring, ceilings, roofing, doors and windows and building finishes.
- **A** detailed schedule of building finishes including colour schemes.
- 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 materials or starting fabrication or construction as applicable.

f)Electrostatic radio interference shielding

The building inside the energized area of the stations shall be electrostatically shielded to limit the exposure of the equipment and personnel to specified electric field strengths. The shielding system shall be grounded properly.

g)GIS hall/Control Room Building/Colony quarters

Design and construction, including anti termite treatment of GIS hall, control room building, administrative building and colony quarters for each sub- station or switchyard shall be in the scope of the contract. The GIS halls, control room buildings and colony quarters shall be of RCC framed structure of concrete M20 grade. The GIS halls, control room and some other rooms of the control room building shall be fully air conditioned.

Rolling shutters shall be of an approved manufacturer, conforming to the requirements specified in IS: 6248:1979. The type of rolling shutter shall be gear operated type (mechanical). Mechanical type of rolling shutters shall be suitable for operation from both inside and outside with the crank handle or chain gear operating mechanism duly considering the size of wall/column.

Rolling shutters shall be supplied duly considering the type, specified clear width/height of the opening and the location of fixing as indicated in the Drawings prepared by the Contractor.

Shutters shall be built up of interlocking laths 75 mm width between rolling centres formed from cold rolled steel strips. The thickness of the steel strip shall not be less than 0.90 mm for shutters up to 3.50 m width and not less than 1.20 mm for shutters above 3.50 m width. Each lath section shall be continuous single piece without any welded joint.

The guide channels out of mild steel sheets of thickness not less than 3.15 mm shall be of either rolled, pressed or built up construction. The channel shall be of size as stipulated in IS: 6248 for various clear widths of the shutters. Hood covers shall be of mild steel sheets not less than 0.90 mm thick and of approved shape. Rolling shutters shall be provided with a central hasp and staple safety device in addition to one pair of lever locks and sliding locks at the ends.

All component parts of the steel rolling shutter (excepting springs and insides of guide channels) shall be provided with one coat of zinc chrome primer conformity to IS: 2074 at the shop before supply. These surfaces shall be given an additional coat of primer after erection at the site along with the number of coats and type of finish paint as specified in the respective items of works prepared by the Contractor. In case of galvanised rolling shutter, the lath sections, guides, lock plate, bracket plates, suspension shaft and the hood cover shall be hot dip galvanised with a zinc coating containing not less than 97.5 percent pure zinc. The weight of the zinc coating shall be at least 610gms/sq.m.

Guide channels shall be installed truly plumb at the specified location. Bracket plate shall be rigidly fixed with necessary bolts and holdfasts. Workmanship of erection shall ensure strength and rigidity of rolling shutter for trouble free and smooth operation. The rolling shutter with handle gear operation shall be provided.

h)Colony quarter and auxiliary buildings.

All the buildings shall be designed as per drawings enclosed with the Bid document and specification will as per the clauses of the bid document.

i)Finish Schedule

The preliminary indicative finishing schedule is given in subsequent clauses. However, at the time of detailed engineering, EMPLOYER reserves the right to alter the finishing schedule and specifications and such changes shall have no additional financial implication whatsoever to the Employer.

j)Flooring (52 mm Thick)

A. 75 mm flat brick soling on compacted soil, 75 mm thick cement concrete 1:2:4.

B. Double charged jointless vitrified tiles 600x600X12 mm for Control Room, conference room and MCCDB (AC & DC) room, Office, Toilet wall, etc.

C. Antiskid vitrified tiles 600X600X12 mm for Toilet floor.

D. 18 mm thick Granite for Staircase, Steps and Kitchen slab.

E. Acid proof tiles 300X300X12 mm for battery room and wall.

F. Toilet wall ceramic tiles 300X450X12 mm.

G. Chequered terrazo tiles 22mm thick for Ramp and slope surface.

i. Walls

Control room buildings shall have framed superstructure. All walls shall be non-load bearing walls. Minimum thickness of outer walls shall be 230 mm and inner wall should be 125 mm with brick work (ACC Block) jointing Mortar or as specified by the Employer 1:4 cement sand mortar. A 50 mm thick DPC shall be provided at plinth level before starting masonary work.

ii. Plastering

All internal walls shall have minimum 15 mm thick 1:4 cement sand plaster. The ceiling shall have 10 mm thick 1:4 cement sand plaster.

iii. External Finish

All external surfaces shall have painted with weather proof synthetic paints over 20 mm thick cement sand plaster in two layers.

All ceilings shall be white based plastic emulsion paints and the internal walls are also to be provided with plastic emulsion synthetic paints. The outer of the building shall be provided with weather seal coats of synthetic paints.

One coat of Cement Primer has to applied after the Putty works.

<u>Painting details:</u>

Following colour paints of *M/s Berger paints India Ltd., M/s Asian Paints India Ltd. & M/s Kansai Nerolac Paints Ltd. Or equivalent brand* with specified standards are to be followed for all type of buildings.

Sl. No.	Decsription	Berger Paints	Asian Paints	Nerolac Paints
1	Interior wall	3P 0778- Soft Light (Easy Clean)	7907-Candle Wick (AP Royale)	2016P- Lemon balm (Lotus Touch)
2	Exterior wall (body)	2P 0229-Calming Touch (Weather Coat Smooth)	8564- Sweet Dreams (Apex)	4051- Lightest Peach (Excel)
3	Exterior wall (border)	2A 0232- Cookie Crisp (Weather Coat Smooth)	8645-Rich Chocolate (Apex)	2798C- Kitty Kat (Excel)

The following procedure need be adopted for maintaining optimum quality & durability in painting the walls (both internal & external walls).

(a) Internal wall:

(i) The walls are to be applied with 2 coats of water proof putty (JK/ Birla/ Bison make or equivalent) of minimum 2 mm of thickness. After the first coat is applied, minimum of 2 days may be spared for drying up the wall. Then the second coat may be applied over the first coat so that 2mm thickness is achieved & uniformity is maintained.

(ii) After applying the second coat, another 2 days may be spared & then sand paper is to be applied to remove the undulation of the wall.

(iii) White primer (water thin-able / solvent thin-able) of two coat (Berger/Nerolac/ Asian Paints or equivalent) is to be applied.

(iv) Then two coats of colour paints washable Acrlic emlusion paints are to be applied on the wall.

(b) External wall:

(i) The walls are to be applied with 2 coats of water proof putty (JK/ Birla/ Bison make or equivalent) of minimum 2 mm of thickness. After the first coat is applied, minimum of 2 days may be spared for drying up the wall. Then the second coat may be applied over the first coat so that 2mm thickness is achieved & uniformity is maintained.

(ii) Two coats of primer (Weather Coat) are to be applied.

(iii) Then two coats of Water proofing weather coat (Anti-fungal) need to be applied on the wall. The two coats should be applied with an minimum interval of 12 hours in between.

iv. Roof wáter proofing and grading

Prepare the surface by thoroughly cleaning with wire brush followed by power washing making surface free from any foreign particles like dust, oil , Grease etc and allowing the surface to dry properly.

Apply water proofing system over the roof slab as specified below :

(i) 1mm thick single coat of Master Crete M-81 of Choksey Chemicals /Dr. Sealkit Sealcrete (Asian Chemicals)/ mixed with cement in the ratio 1:2 as a prime coat.

(ii) 3mm thick Polymer modified mortar - Cement sand mortar (in prop 1:3) mixed with Master Crete M-81/Dr. Sealkit Sealcrete (Asian Chemicals) @ 15% by weight of cement.

(iii) 1mm thick coat of Master Crete M-81 /Dr. Sealkit Sealcrete (Asian Chemicals) mixed with cement in the ratio 1:2 as final coat.

Over waterproofing layers provide concrete screed of average 30mm thick or as per drawings/ requirements in proportion 1:2:4 (1cement : 2fine aggregate : 4coarse aggregate) (by volume) with 10mm and down well graded aggregates and admixed with a normal plasticizer like Master Plast PL-1 of Choksey Chemicals /Dr. Sealkit Normal Plast (Asian Chemicals)/Rheomac 707 of BASF @ 0.3% by weight of cement and thereafter scoring the top surface of the concrete screed @ 200mm c/c as specified and directed by the Department.

The under bed shall be laid to provide an ultimate run off gradient of 1:120. The extra heavy treatment shall be concrete based with water proof treatment as per the standard to protect the roof from damage due to water logging. Proper slope and adequate no of water drains outlets shall be provided for easy discharge of water from the roof. These drains shall be connected to the main drain. Roof treatment shall be done by authorized/certified personnel from the manufacturer. The warranty for the roof treatment should be submitted to EMPLOYER.

v. Glazing (glass)

Minimum thickness of glazing shall be 5 mm. The glazing for the control room area, which will be air-conditioned shall be provided with double toughened glass each of 5mm thickness. Frosted Glass for Toilets.

vi. False Ceiling

False ceiling shall be provided for Control panel rooms in GIS buildings, control room building and administrative building, kiosk building, Lobby area for all residential buildings along with termal and sound insulation. The details for false ceiling to be provided shall be as below -

Provide Suspended Ceiling which includes Aluminium/G.I perimeter channels of size 0.55mm thick (having one flange of 20mm and another flange of 30mm and a web of 27mm) along with perimeter of ceiling, screw fixed to brick wall/ partition with the help of nylon sleeves and screws, at 610mm c/c. Then suspending G.I. intermediate channels of size 45mm (0.9mm thick with two equal flanges of 15mm each) from the soffit at 1220mm c/c with ceiling angle of width 25mmx10mmx0.55mm thick fixed to soffit with G.I.cleat and steel expansion fasteners. Ceiling section of 0.55mm thickness having knurled web of 51.5mm and two equal flanges of 26mm each with lips of 10.5mm are then fixed to the intermediate channel with the help of connecting clip and in direction perpendicular to the intermediate channel at 457mm c/c, 9.5mm/ 12.5mm tapered edge Gypboard (conforming to IS:2095-1982) is then screw fixed to ceiling section with 25mm long drywall screws at 230mm c/c. Screw fixing is done mechanically either with screw driver or drilling machine with suitable attachment. Finally, the boards are to be jointed and finished so as to have a flush look which includes filling and finishing the tapered and square edges of the boards with jointing compound, joint paper tape and two coats of drywall topcoat suitable for Gypboard complete at all levels as specified and directed. (For light fittings, providing opening for doors, window, ventilators etc, cut out made with frame of perimeter channel supported suitably to be measured and paid separately where necessary). 12.5mm deep panels of approved colour with a recessed flange of 23.9mm roll formed out of 0.5mm thick aluminium alloy 5050/5052/3003 or equivalent, coated with

chromatised and stone enamelled on both sides, panels to be fixed on roll formed carriers 32 mm wide 39 mm deep out of minimum 0.9 mm thick aluminium alloy strip with cut outs to hold panels in a module of 100mm minimum at maximum 1.6 mc/c carrier suspended from roof by 4mm diameter galvanised steel wire rod hangers with special height adjustment springs/clips made out of spring steel at maximum spacing of 1.5 m c/c hangers fixed to roof, J'hooks and nylon insert including providing laying and fixing 25mm thick resin bonded mineral wool of approved quality, encased in 100 G black polythene and laid over top of places panels, all complete. The system is subject to approval by EMPLOYER before installation

vii. Doors and Windows

a) Switchyard buildings and security booth

Providing, fitting and fixing Ivory powder coated aluminuim framed glazed doors with anodised aluminium frame made of 100mm x 45mm x 2.5mm section with door style of size

88mm x 45mm x 2.5mm, top rails 50mm x 45mm x 2mm lock rails 100mm x 45mm x 2mm and bottom rails 100mm x 45mm x 2.5mm fitted with glazing clip, special type rubber gasket complete including hydraulic floor spring, pivot, tower bolt in each leaf, aluminium door handle, lock, angles, cleat etc complete as specified and directed by the department at all levels. (i) 10 mm toughened glass

The doors and windows of the control room building, GIS building and security booth shall be of Ivory powder coated aluminium with M.S grill and all the frames of doors and windows shall also be the same as per the relevant IS Codes. Thickness of the aluminium section shall not be less then 2.0mm. Size and shapes shall be adequate for entering in to the room. The windows shall be of sliding type. The **window sill** shall be of 20mm granite.

Alumnium work for doors and windows, ventilators and partitions shall be provided and fixed in the building with extruded built up standard tubular and other sections approved make confirming to IS:733 and IS:1285,anodised transparent or dyed to required shade according to IS:1868 (minimum anodic coating of grade AC 15) fixed with rawl plugs and screws with fixing clips, or with expansion hold fastners including necessary filling up of gaps at junctions at top, bottom and sides with required PVC/neoprene felt etc and joined mechanically wherever required including cleat angle, Aluminium snap beading for glazing/panelling, C.P brass/stainless steel screws including glazing and fittings as specified.

Minimum section for aluminium doors & windows: Main outer size- 100mmX45mmX2.5mm; Horizontal & verical four track- 100mmX45mmX2.5mm; Sliding shutter Horizontal & Vertical- 100mmX45mmX2.5mm;

Necessary hardware like locking arrangement with pin cylinder locks, dead locks, mortised locks, SS baby latch (occupied / vacant) SS push / pull or mortised handle, heavy quality hinges / pivot, concealed tower bolts, etc., of approved make & design. Floor springs and door closer shall be provided.

b) Residential buildings - All other quarter and hostel buildings shall have factory made wooden paneled doors with WPC chowkaths of size 150 x 75 mm and laminate. The thickness of the panel shall be 35mm. Flush door shutters of the solid core type with plywood face panels shall conform to IS: 2202 (Part 1) and with particle board/hard board face panels shall conform to IS: 2202 (Part 2).

Windows for all building shall be Ivory powder coated aluminum sliding windows and ventilators of standard sections as required complete as specified and directed for all levels. All window shall have sliding panel of mosquito proof net made of carbon fiber.

The window grill shall be made of: outer frame and two (2) intermediate vertical frame made of 50X25X1.5 mm MS tube, horizontal member 16mm round bar @ 100 mm centre to centre. Finishing with primer and enamel paint.

Proper locking arrangement with stoppers to be provided on the door and windows. Care should be taken while designing the grill frame that the entering of cat should be restricted.

viii) Plumbing And Sanitation

Sanitation and plumbing shall be done as per requirement as complete. CPVC pipe shall be used for internal piping works for portable water supply. Any item required other than those mentioned below for completing the job shall be provided by EPC without an additional cost.

Each toilet shall have the following minimum fittings

All sanitary fixtures and fittings shall be of approved quality and type manufactured by well known manufactures. All items brought to site must bear identification marks of the type of the Manufacturer. All sanitary and plumbing Works shall be done such that the pipelines are taken via outer wall and internal/concealed piping shall be avoided as far as possible.

	Items
1.	Providing and fixing white vitreous china pedestal type water closet (European type) with seat and lid, 10 litre low level white vitreous china flushing cistern & C.P. flush bend with fittings & C.I. brackets, 40 mm flush bend, overflow arrangement with specials of standard make and mosquito proof coupling of approved municipal design complete, including painting of fittings and brackets, cutting and making good the walls and floors wherever required : 1W.C . pan with ISI marked white solid plastic seat and lid
2.	Providing and fixing white vitreous china flat back or wall corner type lipped front urinal basin of 430x260x350mm and 430x410x265mm sizes respectively with automatic flushing cistern with standard flush pipe and CP brass spreaders with brass unios and GI clamps complete including painting of fitting and bracketscutting and making good the walls and floors wherever required One urinal basin with 5 ltr white PVC automatic flushing cistern. **For ladies toilet Indian WC shall be provided.**
3.	Providing and fixing wash basin with CI brackets 15mm CP brass pillar taps 32mm CP brass waste of standard pattern including painting of fittings and brackets cutting and making good the walls wherever require White vitreous china wash basin size 630x450mm with a pair of 15 mm CP brass pillar taps
4.	Providing and fixing 600x450mm beveled edge mirror of superior glass (of approved quality) complete with6mm thick hard board ground fixed to wooden cleats with CP brass screws and washers complete
5.	Providing and fixing Stainless Steel A ISI 304 (18/8) kitchen sink as per IS:13983 with C.I. brackets and stainless steel plug 40 mm, including painting of fittings and brackets, cutting and making good the walls wherever required : 610x510 mm bowl depth 200 mm
6.	Providing and fixing PTMT swivelling shower, 15 mm nominal bore, weighing not less than 40gms
7.	Providing and fixing PTMT soap Dish Holder having length of 138mm, breadth 102mm, height of 75mm withconcealed fitting arrangements, weighing not less than 106 gms.
8.	Providing and fixing PTMT towel rail and hanger complete with brackets fixed to wooden cleats with CP brass screws with concealed fittings arrangement of approved quality and colour. 600 mm long towel rail with total length of 645 mm, width 78 mm and effective height of 88 mm, weighing not less than 190 gms.
9.	*Supplying fitting and fixing supreme brand / Prince brand or similar approved C.P.V.C. Pipes of following*

ix) Building storm water drainage

The building design shall provide for the collection of storm water from the roofs. This water shall be collected in junction boxes and these boxes shall drain to the main drainage system of the station.

110 mm nominal dia PVC pipe rain water of 6kg shall be provided to drain off the rain water from the roof. These shall be suitably concealed with masonry work of cement concrete or cladding material. The number and size of down comers shall be governed by IS:1742 and IS:2527.

All drains inside the buildings shall have minimum 40 mm thick grating covers and in areas subject to movement heavy equipment loads, precast RCC covers shall be provided in place of steel grating.

For all buildings, suitable arrangement for draining water collected from equipment blow downs, leakages, floor washings, firefighting etc. shall be provided for each floor.

x)Plinth Protection

Entire area around the control room building (outside) shall be provided with PCC paving starting from the building upto 1 mtrs clear distance for the full length of the building. The above specified PCC paving shall be with M20 mix grade concrete over suitable under bed arrangement as specified for other ground floor slab.Above the PCC paving suitable Cement pavers chequered plate of size as per the standard to be provided. The colour of the chequered plate shall be fixed over the PCC paving by using cement mortar and the colour of such plate shall be red.

The cable vault below the main control room shall have 50 mm thick smooth floor finish units of cement concrete.

xi) Staircase - Staircase of all type of buildings shall have stainless steel pf 304 grade in hand railing using 50mm dia of 2mm thick circular pipe with balustrade of size 32mmx32mmx32mm @0.90mtr C/C and stainless square pipe bracing of size 32mmx32mmx32mm in three rows in staircase as per approved design and specification, buffing, polishing.

All stairs shall have maximum riser height of 150 mm and a minimum tread width of 250 mm. Minimum width of stairs shall be 1200 mm. There shall be provision of staircase to the roof of the building.

xii. Illumination System

The Contractor shall design, supply and install illumination system for the entire substation. The average illumination level and limiting glare index for different parts of the substation shall be as follows.

Sl. No	Location/ Area	Average Illumination Level, 'Lux'	Limiting Glare Index
1.	GIS hall	300	19
2.	Control Room	300	19
3.	Battery Room	100	19
4.	Carrier Room	300	-
5.	Office/Conference Room	300	-
6.	Stairs and Corridors	100	-
7.	Outdoor Switchyard	20	-
8.	Road	20	-
9.	Store Room	100	-

The lighting system of a particular área whether indoor or outdoor shall be designed such a way that uniform illumination leve lis achieved. In outdoor swithcyard illumination shall be aimed as far as posible towards transformenrs, circuit breakers, isolators, etc. Typw of lamp used shall be LED. Provisions shall be made in switchyard Steel structures for mounting of lamps for switchyard.

xiii. Internal Electrification

It is in the scope of the contractor to design, instalkl and commisioning of the complete electrification scheme of buildings. Some of the general requirements of the internal electrification Works are as follows:

a) The internal electrification Works shall be carried out in concealed wiring system with rigid conduits and 1.1 kV grade PVC insulated, stranded copper conductors.
b) Illumination level and type of lighting in various locations shall be as specified.
c) Sufficient numbers of 3 pin 6 ampere and 16 amppere sockets shall be provided at various locations as directed by the Employer.
d) No re-wire able fuses shall be used in electrical distribution circuits, instead sufficient numbers of MCBs of short circuitrating of not less than 10 KA should be provided.
e) In conceal wiring the earth wire shall be 1.1 kV grade PVC insulated, stranded copper conductor.

Items	**Unit**	**Quantity**							
		RE's Residenc e	**Officers Hostel**	**Staff Hostel**	**Security Barrack**	**Store Room**	**Guard Room**	**Transit Camp**	
Light & fan Point (First Point)	No.	8	18	16	18	4	4	4	
Light & fan Point (second Point)	No.	22	50	64	50	16	14	10	
Call bell point including MS Box of Size 180mmx100mmx60mm deep for Call bell	No.	2	2	2	2	2	2	4	
3 pin 6 amp plug point including earthing the 3rd pin (power Point)	No.	5	10	8	10	4	4	4	
3 pin 16 amp plug point including earthing the 3rd pin (power Point)	No.	4	7	8	7	1	1	2	
Supply & erection of PVC Copper insulated & sheathed 2 Wire circular flexible wire size 4Sq.mm(power point)	Job		1	1	1	1	1	1	
Supply & erection of PVC Copper insulated & sheathed 2 Wire circular flexible wire size 2.50 Sq.mm(power point)	Job	1							
Supply & erection of PVC sheathed copper conductor cable single core 1100V grade in sizing 6 Sq mm (AC Point)	Job		1	1	1	1	1		

Items	**Unit**	**Quantity**							
		RE's Residence	**Officers Hostel**	**Staff Hostel**	**Security Barrack**	**Store Room**	**Guard Room**	**Transit Camp**	
Supply & erection of PVC sheathed copper conductor cable single core 1100V grade in sizing 4Sq mm (AC Point)	Job	1							
Supply & errection of 25 Amp DP MCCB (AC point)	No.	5	8	7	8	1	1		
supply & errection of 16 Amp DP MCCB (Exhaust fan point)	No.								
Supply & erection of sheet steel enclosure distribution board suitable for MCB,s etc on wall with rag bolts - 12 Way (Three Pole) Including SPMCB 10 No 6-32A & incomer DPMCB 63 A	No.	1	1	1	1	1	1	2	
Supply & erection of MCCB on wall or on pedestal including bonding to earth & necessary connections-200Amp,415 V ,3phase	No.	1	1	1	1	1			
Supply & erection of MCB in existing distribution board including making connection complete with									
16 Amps SPMCB	No.	10	20	16	20	6	6	6	
25 Amps SPMCB	No.	9	17	12	17	6	5	4	
40 Amps DP MCB	No.	1	2	1	2	1	2	2	
63 Amps FPMCB	No.	1							
Call bell 220/230V with double coil	No.	2	2	2	2	2	2		
Bell Push	No.	2	2	2	2	2	2	4	
Supply & erection of 10.5cm dia MS Fan boxes	No.	6	10	10	10	2	2	4	
Supply & erection of 9W LED	No.	16	16	28	16	2	2	4	

Items	Unit	Quantity							
		RE's Residence	Officers Hostel	Staff Hostel	Security Barrack	Store Room	Guard Room	Transit Camp	
Supply & erection 2x24W led tube light	No.	2	4	4	4	5	5	4	
Supply & erection 5w led light	No.	2	15	24	15	4	4	2	
Supply & erection 12w led light	No.	2	10	5	10	5	10		
Ceiling Fans,1400mm Sweep (USHA/CGL)	No.	6	10	10	10	2	2	4	
Exhaust Fans	No.	5	6	8	6	2	4	2	
Industrial Power Socket 32 Amps	No.	1	4	2	4	1	1	2	
Industrial type Exhaust Fans, 1400 RPM,18 Inches	No.								
Cable from ACDB to distribution board Al (4C x 35 sq mm)	Job	1	1	1	1	1	1	1	

xiv. Furniture

Supply and isntallation of all furniture and TV shall be as per the following table -

Sl. No	Items for	Item Description	Qty	Unit
1.	Bed (5'x7') for officer's hostel, staff hostel, transit camp & RE residence	Providing, assembling and placing of Metal double bed with min. dimensions of - H:66cm, L: 203cm, W: 157cm (26 inches x 79.9 inches x 61.8 inches)Headboard H: 45cm, Headboard W: 152cm (17.7 inches x 59.8 inches). The material shall be Teak wood or sheesham wood.	17	Each
2.	Bed (4'x6'5") for house keeping	Providing, assembling and placing of Metal double bed with min. dimensions of - H: 29cm, L: 188cm, W: 97cm (11.4 inches x 74.0 inches x 38.1 inches) Headboard H: 45cm, Headboard W: 91.5cm (17.7 inches x 36.0 inches). The material shall be Teak wood or sheesham wood.	3	Each
3.	Bed (4'x6'10") for security barrack	Providing, assembling and placing of Metal double bed with min. dimensions of - H: 29cm, L: 188cm, W: 97cm (11.4 inches x 74.0 inches x 38.1 inches) Headboard H: 45cm, Headboard W: 91.5cm (17.7 inches x 36.0 inches). The material shall be Teak wood or sheesham wood.	6	Each
4.	Almirah (4'x2'x6') for officer's hostel, staff hostel, transit camp & RE residence, security barrack, store room	Providing and placing of Double door powder coated CRCA steel almirah with 18 gauge steel and min. dimension in cm 91.6 x 198 x 48.6. The Almirah shall have minimum 5 nos. of shelves, an attached mirror and a secure locking mechanism.	34	Each
5.	Almirah (4'x2'x6') for DGM, AGM	Providing and placing of Double door powder coated CRCA steel almirah with min. 18 gauge steel and with min. Dimension in cm 91.6 x 198 x 48.6. The Almirah shall have minimum 5 nos. of shelves, an elevated base and a secure locking	3	Each

Sl. No	Items for	Item Description	Qty	Unit
		mechanism.		
6.	Bed Side Table for officer's hostel, staff hostel, transit camp & RE residence	Providing, assembling and placing of Bedside table made of sheesham wood with min. Dimension of (in cm) 45.7 L X 38.1 W X 40.6 H. The table shall be closed type with min. 2 Nos. of drawers.	34	Each
7.	Table (3'x4') for officer's hostel, staff hostel, transit camp & RE residence, security barrack, store room, guard room	Providing, assembling and placing of study table made of sheesham wood and min. Dimension of Length = 120cm, Width = 60cm, Height = 79.5cm (47.2 inches x 23.6 inches x 31.3 inches). The hardware shall be of 18-inch telescopic Channels, stainless steel handles, hinges, screws, and dowels. The table shall have min. 1 No. of drawer. and a closed compartment.	25	Each
8.	Table (4'x6') for DGM, AGM	Providing, assembling and placing of executive office table made of Engineered Wood and min. Dimension of 220cm (L), 150 cm (W), Height = 75 cm. The table shall have min. 3 Nos. of drawer. and a closed compartment.	3	Each
9.	Executive Chair for DGM	Providing and placing of premium quality chair with High Back Chair, PU Arm, Chrome Plated Metal Frame & Base, Gas Lift with 360o revolving mechanism, Leatherette Tapestry	1	Each
10.	Executive Chair for AGM	Providing and placing of premium quality chair with TYPE/MECHANISM: Synchro Tilt Medium Back Chair , PP Adjustable Arm , Chrome Plated Metal Base, Gas lift Synchro Tilt Mechanism Seat .	2	Each
11.	Visitor Chair	Providing and placing of premium quality visitor's chair with Medium Back, PU Arm, Chrome Plated Frame, Leatherette Tapestry.	50	Each
12.	Sofa Set (3+1+1)	Providing and placing of premium quality 3 Seater Sofa for guest with min. dimension of Length - 204.9 cm, Width - 79.2 cm , Height - 77.9 cm (80.7 inches x31.2 inches x 30.7 inches) for 3 seater and Length - 92.9 cm, Width - 79.2 cm, Height - 77.9 cm (36.6 inches x 31.2 inches x 30.7 inches) for single seater. Sofa With Wooden Frame, seat fill material of foam and seat material shall be fabric.	5	Each
13.	Centre table	Providing and placing of premium quality Centre Table made of engineering wood, Tempered Glass top ,min. Size In MM 991(L) 600(D) 400(H),	5	Each
14.	Dinning Table (6 Seater)	Providing and placing of premium quality 6 seater Dining Table including chairs with understructure of both table and chair made of solid rubberwood, Medium-Density Fibreboard (MDF) Tabletop with 19 cm thickness, Size of table In MM 1500(L) 900(W) 750(H), Size of chairs in mm 430(L) 563(W) 930(H). Chairs shall have Upholstery in cushion type.	4	Each
15.	Dinning Table (4 Seater)	Providing and placing of premium quality 4 seater Dining Table including chairs with Understructure of both table and chair made of solid rubberwood, Medium-Density Fibreboard (MDF) Tabletop with 19 cm thickness,	1	Each

Sl. No	Items for	Item Description	Qty	Unit
		Size of table In MM 1140(L) 700(W) 750(H), Size of chairs in mm 430(L) 563(W) 930(H). Chairs shall have Upholstery in cushion type.		
16.	Computer Table for DGM, AGM	Main table should be rectangular and of size 1500 mm (W) X 750 mm (D). Shall be made of 18 mm thick engineered wood. KBPT used should have a sliding mouse pad tray.	3	Each
17.	Meeting room table (3'x12') 10 seater with chair	Providing and placing of 10 seater conference table with min. dimension of 3000 (L) x 1200 (W) x 760 (H) mm and with a min. of 3 intermediate supports. Material shall be min. 18 mm thick MDF board with laminate. The table shall have min. 2 wire management grommet and min. 4 nos. 16 Amps power socket provision. Chairs shall be of premium quality with High Back, PU Arm, Chrome Plated Metal Frame & Base, Gas Lift with 360o revolving mechanism and Leatherette Tapestry	1	Each
18.	Workstation Table	Providing and placing of workstation table with min. dimension of 1500 (W) x 750 (D) x 750 (H) mm. Material shall be particle board. Storage in three drawer option on one side and the other of size 355.5 (W) x 559(D) x 433.5 (H) mm in one box and one drawer option on the other side.	9	Each
19.	Workstation Chair	Providing and placing of chair for workstation with TYPE/MECHANISM: Medium Back Chair, Chrome Plated pipe frame, material of Upholstery in leatherette type	9	Each
20.	Workstation Almirah	Internal Size of Almirah: 1850 (H) X 900 (W) X 450 (D) mm 2. Leg Size of Almirah: 150 (H) X 120 (W) X 450 (D) mm 3. Rack with 5 Compartments of 4 no. of shelves. 4. Standard lock and 2 sets of keys. 5. The thickness of the Almirah sheet shall be 18 SWG. 6. The body of the Almirah shall be manufactured from cold rolled MS sheet (C. R. Sheet) with Antirust treatment and shall be finished with powder coating. 7. The quality of used M.S sheet for making Almirah shall be free from any pitting and corrosion etc. 8. H/D Rubber bushes shall be provided to the bottom of legs of Almirah.	8	Each
21.	Steel book case for record room	914 (W) x 320 (D) x 1742 (H) mm min. dimension. Providing and placing of steel bookcase made of Sheet CR prime 0.80 mm thick Confirming to IS-513. Compartment- 4 no. Six leaver locks of high quality in each shutter operated by one key, supplied with key ring. Chrome plated, metallic handles two nos, on each shutter from outside. Plane glass, 4mm thick in each shutter fitted in suitable frame from inside. Shutter sliding on ball bearing, two nos. in each door with suitable system / double roller system.	3	Each

Sl. No	Items for	Item Description	Qty	Unit
22.	Meeting Room TV	Providing and placing of Sony Bravia/Samsung/LG 164 cm (65 inches) 4K Ultra HD Smart LED TV Specifications: (i) Supports Wifi, bluetooth, USB, HDMI (iii) Media Format: AVI, Blu-ray, DVD, MPEG, WAV, WMA (iv) Supported Audio Format: Mp3_audio, Wma	1	Each
23.	Smart TV for officer's hostel, staff hostel, security barrack, RE residence, transit camp, visitor's lounge	Providing and placing of Sony Bravia/Samsung/LG 108 cm (43 inches) Full HD Smart LED TV Specification: (i) Supports Wifi, bluetooth, USB, HDMI (ii) Resolution: 1080p (iii) Media Format: AVI, Blu-ray, DVD, MPEG, WAV, WMA (iv) Supported Audio Format: Mp3_audio, Wma	11	Each
24.	Modular TV unit for setup	Providing, fitting, fixing and placing of Tv unit made of engineered wood with min. Dimension in cm 152.4 L X 45.7 W X 50.8 H. The unit shall have min. 2 drawers on one side and closed type storage on other side.	12	Each

b) MISCELLANEOUS GENERAL REQUIREMENTS

Dense concrete with controlled water cement ratio, preferably 0.45, shall be used for all underground concrete structures such as pump-house, tanks, water retaining structures, cable and pipe trenches etc. for achieving water-tightness. All joints including construction and expansion joints for the water retaining structures shall be made water tight by using PVC ribbed water stops with general 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 by sea shall be provided with anti- corrosives paint. All mild steel parts used in the water retaining structure shall be hot-dip galvanised. The minimum coating of the zinc shall be 750 gm/sq.m. for galvanised structures and shall comply with IS:2629 and IS:2633. Galvanizing shall be checked and tested in accordance with IS:2629. The galvanizing shall be followed by the application of an etching primer and dipping in black bitumen. A screed concrete layer not less than 100 mm thick and of grade not weaker than M10 conforming to IS:456- 1978, shall be provided below all water retaining structures. A sliding layer of bitumen paper or craft paper shall be provided over the screed layer to destroy the bond between the screed and the base slab concrete of the water retaining structures. Bricks having minimum 75kg/sq.cm compressive strength can only be used for masonry work. Bidder shall ascertain himself at site regarding the availability of bricks of minimum 75kg/ sq.cm compressive strength before submitting his offer. Monorails, monorail girders and fixtures shall be provided, wherever required. Doors and windows on external walls of buildings other than areas provided with insulated metal claddings shall be provided with a RCC sun- shade over the openings with 300 mm projection on either side of the openings. **Projection of sunshade/chajja from the wall shall be minimum 450 mm over window openings and 750 mm over door openings. All slabs shall be extended by 600 from the wall and parapet wall shall be on the Edge of the slab. All balconies shall be covered from rain by extending the roof slab on upper level.**

Drainage hole shall be provided in the roof slabs such that the pipes for rain waiter drainage can be fitted to these holes and cladded to the building wall without bends. The columns in all buildings shall be extended by 750 mm above roof slab level to keep provision for future extension. Irrespective of drawing the mumty height shall be kept at the same level as the previous floor height .

Angles of 50x50x6 mm minimum with lugs shall be provided for edge protection all round cut out and openings in floor slab, edges of drains with grating covers, edges of RCC cable/pipe trenches with covers, edges of manholes with covers, edges of precast covers and any other place where breakage of corners of concrete is expected.

Anti-termite chemical treatment shall be given to column pits, wall trenches, foundations of buildings, filling below the floors etc. as per IS:6313 and other relevant Indian Standards.

Hand railing of a minimum height of 900 mm shall be provided around all floor or roof openings, projections and balconies walkways, platforms, steel stairs etc. All handrails and ladder pipes shall be the railing of the staircase shall be made of proper aluminium sections.

5.10 AUTO TRANSFORMER / REACTOR & EQUIPMENT FOUNDATIONS

a) **General -** The Contractor shall provide a permanent transfer track system integrated with the auto transformer foundation to enable installation and the replacement of any failed unit with a spare unit. The transfer track system shall be suitable to permit the movement of any failed unit fully assembled (including OLTC, bushings) with integral radiators and oil, without the de-energization of any other equipment in the station. The system shall enable the removal of any failed unit from its foundation to a repair area and the installation of a spare unit. The system shall not interfere with the normal internal road and trench system. If trench or drain crossings are required, then suitable R.C.C culverts shall be provided in accordance with IRC Code and /or relevant IS.

b) Oil Recovery System

i. General

An oil recovery system shall be provided for all transformers (containing insulating oil or any flammable or polluting liquid) in order to avoid spread of fire by the oil, and for environmental protection.

ii. Description

Each auto transformer/transformer including oil conservator tank and cooler banks etc. shall be placed in a transformer pit surrounded by retaining walls (pit walls). The clear distance of the retaining wall from the transformer shall be 20% of the transformer height or 0.8 m whichever is greater. The transformer pit thus formed shall have a capacity equal to volume of oil, usually 125%, in the transformers. The MS grating placed at the formation level shall be covered with 100mm thick gravel of 40 mm nominal size which acts as an extinguisher for flaming oil. The bottom of the pit shall have an uniform slope towards the sump pit.

Each transformer pit shall be drained towards a common sump pit whose role is to recover the infiltrating water and the drained oil from of the pit. The sump pit shall have sufficient capacity to receive, without overflowing, the oil content of large transformers plus the water content of any fixed firefighting system and a certain quantity of rainwater collected from the pit connected to it. The system shall be provided with air vents large enough to avoid over-pressure during operation. The whole internal surface of the sump pit should be impermeable.

iii. Materials

The retaining walls which make up the transformer pit shall be made of fire-resistant material such as reinforced cement concrete, fire brick etc., and shall be impervious to oil.

The minimum height of the retaining walls shall be 15 cm above the finished level of the ground to avoid ingress of water from outside.

The floor of the transformer pit shall be of plain cement concrete of concrete grade 1:2:4.

iv. Drainage

A device showing level of sump pit shall be fitted along with an automatic pumping system which shall have sufficient capacity to evacuate the fire fighting and rainwater from the sump pit. The water/oil separation and drainage scheme shall be provided as described in the paper (23-07/1972 Cigre Session) presented by working group 23.04 regarding oil pollution. The Contractor may propose an alternative better scheme, which will be subject to the approval of EMPLOYER.

v. Particular Specification

If the height of the retaining walls which form the transformer pit exceed 60 cm, steps shall be provided to facilitate access to the transformer or auto transformer and reactor.

When designing the transformer pit, the movement of the auto transformer must be taken into account.

It must be assured that the coefficient of crushed stone (granular material) penetration which fills the transformer pit will be retained regardless of the climatic conditions

5.11 RAIL TRACK / ROAD CUM RAIL TRACK

Rail tracks shall be of RCC, M20 (1:1.5:3 mix) grade. The space between the tracks shall be suitably filled with local sand and 75 mm thick PCC of grade 1:3:6 placed over sand filling. The top of PCC shall be up to the formation level. In case of road cum rail track, 75mm thick PCC of grade 1:1.5:3 shall be placed up to the road level. Suitable drainage system between the tracks shall be provided.

The rails shall be first quality 52 kg/m medium manganese steel as per Indian Railway specification T-12-64 and its subsequent revision, joined together by fish plates as per Indian Railway specification T-1/57, and 27 mm diameter fish bolts.

A pylon support system shall be provided for supporting the firefighting system by the Contractor.

For design of foundation for transformer refer the weightage of the transformer indicated in the BPS (civil works)

5.12 FIRE PROTECTION WALLS

a) General

Fire protection walls shall be provided in accordance with as per IS 1646:2015 recommendations.

b) Application criteria

A fire wall shall be erected between the transformers and or the reactors if the free distance between the various pieces of equipment is less than 10 m, to protect each one from the effects of fire on another.

Fire walls shall also be erected between the transformers, reactors, and auxiliary services transformers if the free distance is less than ten meters.

***c)* Fire resistance**

The fire wall shall have a minimum fire resistance of three hours. Partitions which are made to reduce the noise level of the transformers shall have the same fire resistance where they are also used as fire walls. The walls of buildings which are used as fire walls, shall also have a minimum fire resistance of three hours.
Fire walls shall be designed in order to protect against the effect of radiant heat and flying debris from an adjacent fire. The column of the fire walls shall be type be RCC, M20 (1:1.5:3 mix).

d) Mechanical resistance

Fire walls shall have the mechanical resistance to withstand local atmospheric conditions. If the wall is intended to serve as a support for equipment such as insulators etc., its mechanical rigidity must be increased accordingly.

Connecting the walls by steel or other structures, which may produce a reversing torque if overheated, shall be avoided.

e) Dimensions

Fire walls shall extend at least two metres on each side of the power transformers or reactors and at least one metre above the conservator tank or safety vent.

These dimensions might be reduced in special cases, and if TAC permits so, where there is lack of space. A minimum of two metres clearance shall be provided between the euqipments e.g. reactors, transformers and fire walls.

Building walls which act as fire walls shall extend at least one metre above the roof in order to protect it.

f) Materials

Fire walls shall be made of Reinforced Cement Concrete (RCC of M20 grade) only. Materials used must conform to the standards of the National Fire Prevention Association and TAC norms.

5.13 CABLE AND PIPE TRENCHES

a) **General**

Drawing for cable trench is attached with this bid document.

Cable trenches and pre-cast removable RCC covers (with lifting arrangement) shall be constructed using RCC of M20 grade.

The cable trenches shall be designed for the following loads.

- Cable trench covers shall be designed for (i) self-weight of top slab plus concentrated load of 200 kg at centre of span on each panel and a surcharge load of 2 tonnes per sq. metre.
- Cable trench crossings of road and rails shall be designed for class AA, class A and class 7OR loading of IRC or relevant IS Code and should be checked for transformer loading.
- Trenches shall be drained. Necessary sumps be constructed, and sump pumps shall be supplied. Cable trenches shall not be used as storm water drains.
- The top of trenches shall be kept at least 300 mm above the finished ground level. The top of cable trench shall be such that the surface rainwater does not enter the trench.
- All metal parts inside the trench shall be connected to the earthing system.
- Cables from trench to equipment shall run in hard conduit pipes (HDPE pipe, ends and sockets). A suitable clear gap shall be maintained between trench walls and foundations.
- A clear (vertical) space of at least 300 mm shall be available for each tier in cable trench. From trench bed to lowest tier, a minimum clearance of 200 mm shall be available for one tier trench and 300 mm for trenches having more than one tier. The spacing between stands shall be 400mm.
- The trench bed shall have a slope of 1/500 along the run and 1/250 perpendicular to the run.

All construction joints of cable trenches i.e. between base slab to base slab and the junction of vertical wall to base slab, as well as from vertical wall to wall, and all expansion joints shall be provided with approved quality PVC water stops of approximately 230 x 5 mm size for those sections where the ground water table is expected to rise above the junction of base slab and vertical wall of cable trenches.

Cable trenches shall be blocked at the ends if required with brick masonry in cement sand mortar 1:6 and plaster with 12mm thick 1:6 cement sand mortar.

Cable tray supports (all galvanized structures) shall be designed and constructed to be a single complete fabrication or assembly such that every layer of the horizontal cable tray supports is fixed, either bolted or welded, to a vertical steel support that is embedded in the concrete wall of the cable trough. It shall not be permitted to embed a horizontal support beam directly into the wall of the trough in order to use the concrete wall as a means of load bearing.

Concrete troughs shall be provided with concrete covers of suitable load bearing strength. Where the cable troughs are run across or within 3 m of substation roads, the trough covers shall be capable of bearing an accidental wheel load of 20 kN.

The covers for the cable trench inside the control room shall be provided with MS chequered plate with MS angle stiffeners at the bottom for proper mechanical strength.

b) **Excavation***Excavation for cable ducts shall generally be carried out in accordance with specification.*

c) **Back fill**

Except where ducts are to be encased in concrete, sand is to be packed and well tamped round the duct until it is covered to a depth of 75 mm above the upper surface of the duct. Filling above this level is to be with suitable excavated material free from large stones. In multiple duct runs the interstices between the ducts are to be filled with sand and compacted. A cover of 75 mm above the uppermost ducts shall be maintained. The sand used shall be the same quality as approved for use in making concrete.

d) **Laying of ducts**

Telephone and electrical cable ducts shall be laid and jointed in accordance with the Manufacturer's instructions.

e) **Multiple runs to ducts**

Electrical cable ducts in multiple runs whether encased in concrete or not, shall be laid at approved centres vertically and/or horizontally. The minimum concrete encasement where required is to be 150 mm. The final jointing of ducts in multiple runs shall be done in the trench, i.e. the duct shall be lowered and jointed singly not in groups, and duct joints shall be staggered by approximately half the duct length in alternate lines.

f) **Cutting of ducts**

The Contractor shall carry out any necessary cutting of pipe ducts according to the requirements of the work. Except where ducts enter the cable trench at an angle, they shall be cut at right angles to the length of the duct. The inside edges of cut ducts shall be thoroughly rounded off or so dressed before being placed in position so that there can be no possibility of damage to cables from the edges of the ducts. All electrical ducts entering draw pits shall be provided with suitable bell mouths.

g) **Cleaning and testing of ducts**

On completion of all electrical cable ducting, two mops of appropriate size connected one to each end of an iron mandrel shall be passed twice through each way to clean the conduit and to remove any foreign matter which may have entered. If any obstruction or other defect be discovered, it shall be removed or rectified forthwith.

h) **Sealing of electrical ducts**

As soon as every duct or set of ducts has been proved and its draw wire material installed, the ends of the cut or its bell mouth where provided, shall be sealed to a depth of 5 mm with an appropriate sealer, and a single coat of bitumastic paint shall then be applied over the end of the ducts and the seal. The length of draw wire installed shall be such that at least one metre of draw wire extends from each end of each duct. After the ends of ducts have been sealed the free ends of draw wires shall be neatly coiled.

i) **Concrete cable and pipe trenches**

In-situ concrete trenches are to be provided inside and outside the Substation. The trenches are to have falls in the floor and must be drained at regular intervals. All trenches must have trench covers suitable for their location and loading. Any beams or supporting covers must be as shallow as possible to avoid interfering with the pipes and cables in the trench. Once the trench covers have been made they are to be stored and not laid until all trench cabling, piping, etc. is finished. Any covers laid before this time which become damaged shall be replaced at the Contractor's expense. Trench covers and bridging beams for covers, except where heavy duty, shall be light enough for two men to lift.

j) **Buried cables**

Cables are to be laid in neat lines and at suitable levels. Their depth below ground level will depend upon the voltage associated with the cables but in all cases the excavation must provide a clear trench. Sand filling below, around and above the cables will always be required and protection covers or tiles will be placed in position over the sand filling before final backfilling to the ground level. The line of the cable trenches shall be marked with suitable posts as required by relevant section of this Specification.

5.14 SEWAGE SYSTEM & STORM WATER DRAIN

a) Sewage System - A sewage system shall be provided for all utility buildings including the Control room building and other auxiliary buildings. The Contractor shall construct suitable septic tank (capacity 30 user minimum) and soak pit for the discharge of effluents. Sewers shall be designed for a minimum self-cleansing velocity of 0.6m/sec and the maximum velocity shall not exceed 2.4m/sec.

The sewage system shall consist of all necessary piping, pumps, if required, fittings, manholes, clean - outs, piping connections and all other materials required for safe and efficient sewage collection. Sewer pipes and fittings shall conform to the relevant Indian Standards.

UPVC pipes shall be used below ground level for sewage disposal.

b) Storm Water Drain

Storm Water drainage system shall be provided along both side of the road as well as surrounding the campus and switchyard. The Contractor shall obtain rainfall data and design the storm water drainage system, (culverts, ditches, drains etc.) to accommodate the most intense rainfall that is likely to occur over the catchment area in one-hour period on an average of once per ten years. The surfaces of the site shall be sloped to prevent the ponding of water. The bottom of the drain should be minimum 600mm wide. The side wall should be minimum 2:1 slope. 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. Longitudinal bed slope not milder than 1:500 shall be provided. For design of RCC box culvert for drains and culverts, IS 456 and IS 783 shall be followed. The Contractor shall ensure that water drains are away from the site area and shall prevent damage to adjacent property by this water. Adequate protection shall be given to site surfaces, roads, ditches, culverts, etc., to prevent erosion of material by water. The drainage system shall be adequate without the use of cable or pipe trenches. For road crossings RCC box culvert shall be provided. Manholes shall be provided at 30 m intervals, at connection points and at every change of alignment. All manholes deeper than 1.2 m shall be provided with galvanized M.S. footrests. Footrests shall be of 20 mm M.S. square bars. Open surface drains shall be of RCC (1:1.5:3) type. Design and drawings shall have the approval of EMPLOYER. For expansive soils, the guidelines of IS 9451 shall be followed. Suitable expansion joints shall be provided as per standard. In general, all plant effluent drainage shall be through buried concrete pipes and all storm water drainage shall be through open drains/pipe drains. Open storm water drains shall be provided on both sides of the roads and shall be designed to drain the road surface as well as all the free and covered areas. Pipe drains shall be connected through manholes at an interval of maximum 30 m. Plant effluents shall be suitably treated by the Contractor to meet all the prevalent statutory requirements and local pollution control norms and treated effluents shall be conveyed to the storm water drainage system at a suitable location for their final disposal. Invert of the drainage system shall be decided in such a way that the water can easily be discharged above the High Flood Level (HFL) outside substation boundary at suitable location and approved by EMPLOYER. Pumping of drainage water, if required, shall be provided by Contractor. All internal site drainage systems, including the final connection and disposal to Authorized representative of EMPLOYER acceptance points shall be part of Contractor`s scope including all required civil work, mechanical and electrical systems. The Contractor shall connect his drain(s) at one or more points.

Precast manholes shall be preferred against cast-in-situ type. The drainage scheme may either employ open drain system or underground pipe system or a combination of both. A manhole shall be provided at every turn or corner in case of underground type in addition to the normal requirement.

Suitable pumping arrangement shall be provided by the Contractor to pump out the water from sump to the open channel; automatic float valve type pump shall be provided and installed by Contractor.

The Contractor shall locate the outfall point outside the substation vicinity and the substation storm drainage must be connected to this point.

The drainage scheme and associated drawings shall be subject to approval of EMPLOYER.

i. Excavation and backfill

Trench excavations for drains shall be carried out with the minimum disturbance to adjacent ground and in such a way that existing or new work shall not be undermined. No backfill shall be placed until pipes, etc. have been inspected, tested and approved. Backfill shall be carefully placed by hand tools round pipes, etc. and rammed in layers not exceeding one hundred (100) millimetres thick in a manner which will not cause damage. When a minimum thickness of three hundred (300) millimetres above the pipes has been so placed, normal methods of backfilling and ramming may be adopted.

ii. Laying Of Pipes

Pipes and fittings shall be of the types, qualities and sizes specified and shown on the approved drawings. They shall be laid to the lines and levels shown, and the barrel of each pipe shall bear firmly and uniformly on the trench bottom or prepared foundation bed, any projections in the trench bottom which could cause damage to pipes being first removed. Pipes shall be kept clean during and after laying, and open ends shall be provided with the temporary plugs to prevent entry of foreign matter. Each pipe shall be accurately bonded to gradient between sight rails and drain. Laying shall commence at the lowest end and proceed uphill. Pipes shall be laid with the sockets leading uphill.

iii. Testing of drains

All drains, other than open channels, stone filled drains and porous drains, shall be of watertight construction, and all soil drains shall be subjected to a water test before backfilling of trenches is commenced. Drains may be tested in sections, and manholes may be tested separately. The Contractor shall submit to EMPLOYER for approval his proposals for testing. The drains shall withstand, without leakage, a water pressure of not less than one and one half (1.5) metres at any point for a period of 20 minutes or such other time as EMPLOYER may direct. All necessary plugs, temporary connections and other equipment and all labour required for the tests shall be provided by the Contractor and at the expense of the Contractor. For testing of pipes in areas where an adequate supply of water is not readily available, EMPLOYER will accept an air (smoke) pressure test, provided that the method of testing is approved by EMPLOYER. Further testing may be called for after backfilling of trenches to ensure that pipes have not been damaged during that operation.

iv. Regulations

The regulations and recommendations of any relevant drainage or sanitary authority shall be fully observed, and the Contractor shall be responsible for acquainting himself with any such regulations.

5.15 ANTIWEED TREATMENT, SWITCHYARD PCC & GRAVELLING

General Requirement

The material required for site surfacing/gravel filling shall be free from all types of organic materials and shall be of standard approved quality, and as directed by EMPLOYER. The Contractor shall furnish and install the site surfacing to the lines and grades as shown in the drawing and in accordance with the requirements and direction of EMPLOYER. The soil of the periphery area of the switchyard area shall be subjected to sterilisation or anti-weed treatment before placing the site surfacing/gravel fill material or strictly as per instruction or requirement of the manufacturer of the chemical required for soil sterilisation or anti-weed treatment. After all the structures and equipment have been erected and accepted, and soil sterilisation of the peripheral area (except the switch yard area) as specified is complete, the site shall be maintained to the lines and grades indicated in the drawing and rolled or compacted by using three ton roller with suitable water sprinkling to form a smooth and compact surface condition which shall be matching with finished ground level of the switchyard area.

After due compaction of the surface of the entire switchyard area shall be provided with plain cement concrete of 100 mm thickness after proper compaction, and antiweed treatment having cement concrete ratio 1:3:6. Care shall be taken for proper gradient for easy discharge of storm water.

As a final surface course minimum 100 mm uniform layers of uncrushed /crushed broken metals (gravel) of 20 mm. nominal size shall be spread over the base layer/course. This final surface course shall be applied in all areas of switchyard exclusive of roadways up to the fenced area. This surface course shall then be compacted by light roller using 1/2-ton steel roller (width 30”x dia 24”) and 4 to 5 passes or any other means with water sprinkling as directed by EMPLOYER. Water shall be sprinkled in such a manner that bulking does not take place. The 20 mm. nominal size (for both layers) shall pass 100% through IS sieve designation 37.5 mm and nothing through 16.0 mm. IS sieve.
In areas that are considered by EMPLOYER to be too congested with foundations and structures for proper rolling of the site base course material by normal rolling equipment’s, the material shall be compacted by hand, if necessary. Due care shall be exercised so as not to damage any foundation structure or equipment during rolling or compaction. EMPLOYER by no means shall relieve the contractor of their contractual obligations as stipulated in General and Special Conditions of Contract.

Chemical to be used for soil sterilization /anti-weed treatment:

The details of quantities and method of application of chemicals used for soil sterilization /and anti-weed treatment shall be as per manufacturer`s recommendations. Bidders are required to submit the details of chemicals proposed to be used and recommendations of manufacturer with required guarantee along with their bids for necessary approval of EMPLOYER. Approval of EMPLOYER by no means shall relieve the contractor of their contractual obligations as stipulated in General and

Special Conditions of Contract.

5.16 FENCING AND GATE

a) Fencing

Fencing shall be designed for the most critical loading combination taking into account wind forces, stability, tension on wires, minimum requirements as per this clause and relevant IS recommendations.

Minimum specification of fencing:

i) Drawing as per attached with the BID document.

ii) Fencing panel size: 2.5X3.0 mtr with 500 mm extension in V shape for 6 nos. of barbed wire.

iii) Frame: 50X50X5 mm, 50X5 mm bracing.

iv) 6mm rod @ 100 mm C/C.

v) Priming and two coats of painting with enamel paint.

The unclimbable or security, or anti-intruder fencing shall consist of chain link mesh, all as soon on the drawings and as specified below, supported on approved sections of structural steel. The posts shall be erected truly vertical, and all posts and struts shall be set in concrete block foundations.

Concrete kerbing shall be provided between the fence posts as shown on the drawings.

Areas requiring fencing - Fencing shall be provided for the following areas:

- Site fencing for the complete station, complete with barbed wires on top. Separate gates shall be provided for men and equipment.
- Internal fence surrounding the various equipments (if) mounted on ground or a height lower than 2.5 m, without barbed wires on top. Necessary gates shall be provided for each area so surrounded.
- Wherever necessary anti-reptile fixture/arrangement shall be provided along with fencing.

Installations: Fence shall be installed along switch yard line as per the approved GA drawing. Post holes shall be excavated by approved method. All posts shall be 3 mtrs apart measured parallel to ground surface.

Fence posts shall be erected in vertical and kept for minimum 7 days curing before fence erection.

Paintings as per decision of the Engineer in charge have to be carried out.

Continuous running earth by using 50 X 6 mm GI flats to be provided for safety purpose.

A 125mm mm thick (one and a half brick size) toe wall of Brick with tie beam with notches shall be provided below all fencing and shall be minimum 200 mm above and 500 mm below finished ground level. All exposed surfaces for brick toe wall shall be provided with 15 mm 1:4 cement sand plaster and coated with two coats of external weather coat paint. In case if rubble masonry is provided suitable pointing shall be done.

b) Gates shall be installed in locations shown on drawings. Next to the main gate, a men gate (1.25 m wide, single leaf) shall also be provided.

Bottom of gates shall be set approximately 40 mm above ground surface and necessary guiding mechanism (with roller on the bottom of the gate and fixed guider in the road) shall be fitted to avoid hanging of the main gate.

Design of the gate shall be as per attached drawing in the BID document. Gates shall be fabricated with welded joints or other approved methods to achieve rigid connections.

5.17 ROADS AND CULVERTS

The Contractor shall be responsible for constructing approach roads, sub-station roads and service roads etc. within the substation area. Layout of the roads shall be based on general details and arrangement drawings for the substation. Adequate turning space for vehicles shall be provided and bend radius shall be set accordingly. Roads to the transformer bays shall be as short and straight as possible. Where the substation layout warrants headroom safety barriers shall be installed to prevent vehicles coming into contact with overlying conductors. Such barriers shall be included as part of the scope of the work.

Road construction shall be as per Indian Road Congress (IRC) standards.

Adequate provision shall be made for road drainage.

All culverts and allied structures required for road/rail, drain, trench crossings etc. shall be designed for class AA loading as per IRC standard.

At the junction of the hard standing and roads due to different thickness of foundations, precautions shall be taken to ensure that sub-surface drainage from the hard standing does not have a detrimental effect upon the road foundations.

a) INTER LOCKING CONCRETE BLOCK PAVEMENT (ICBP) BLOCK ROAD:

The side shoulder of all the roads shall be with kerb stone at two sides. The kerb stones shall be painted yellow and black alternatively. In case of switch yard road (concrete road) the shoulder would be compacted earth 600 mm wide on the sides of the road. The inter locking concrete block pavement (ICBP) block road shall have minimum 80 mm thick. Below it 150 mm thick water bound macadam (WBM) in two equal layers of 75 mm each at the bottom and minimum 200mm granular sub-base.

Minimum two layers of 100 mm thick GSB (200 mm), two layes of 100 mm thick WBM (200 mm) along with 80 mm thick Inter-locking Concrete Block Pavement (ICBP) and M20 PCC kerb of size 300 mm width and 500 mm depth. The side shoulder of all the roads shall be with kerb stone at two sides. The kerb stones shall be painted yellow and black alternatively. the shoulder would be compacted earth 600 mm wide on the sides of the road.

5.18 FOUNDATION AND RCC CONSTRUCTION

a) General

Work covered under this Clause of this Specification comprises the design, supply and installation of foundations and other RCC constructions for switchyard structures, equipment supports, trenches, rains, jacking pads, pulling blocks, fencing, control cubicles, bus supports, transformers, marshalling kiosks, auxiliary equipments and systems, buildings and tanks, 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.

Concrete shall conform to the requirements of IS 456 and all the tests shall be conducted as per relevant Indian Standard Codes in Addition to total 9 nos of cube has to be prepare for 7 days , 14 days & 28days

If the site is sloping, the foundation height will be adjusted to maintain the exact level of the top of structures to compensate for such slopes.
If the site is located in depressed areas or in low land areas and soil filling has to be required by 2 mtrs and above , such type of sites a pile foundation shall required to adopt for all type of swichyard structures , RCC buildings and supporting structures except boundary walls and minor civil works, a minimum two piles shall be provided in any pile group.
Minimum height of the pedestal shall not be less than 650 mm above FGL exclusively where the site is located in depressed areas or low lands and the foundation has to be located in filled up soil height by 2mtrs and above
A minimum of 75 mm thick lean mix concrete (1:3:6) shall be provided below all underground structures, foundations, trenches etc. to provide a base for construction.

Concrete made with portland cement (OPC-43 grade) shall be carefully cured and special consideration shall be given during the placing of concrete and removal of shuttering.

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 combinations thereof. Spread footing foundations or pile foundations as may be required based on soil and subsoil conditions and superimposed loads shall be provided.
If pile foundations are adopted, the same shall be cast-in-situ, driven, bored, precast or underreamed type as per relevant IS. 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 and pile groups proposed to be used. Necessary initial load tests shall also be carried out by the contractor at their entire cost to establish the pile design capacity. Only after the design capacity of piles has been established, shall the Contractor commence of piling. All the design and testing work shall be planned in such a way that these shall not cause any delay in project completion.

b) Cement

The cement to be used shall be the best quality of its type.

All cement shall be sampled and tested in accordance with Indian Standards.

Cement shall be Ordinary Portland Cement (OPC)
or Portland Pozzolona Cement (PPC) as per I.S.269-1976 or Portland Slag Cement as per I.S. 455 1976 The Ordinary Portland cement (OPC-43 grade) used in concrete shall confirm to IS 269.

Requirement of sulphate resistant cement (SRC) for sub structural works shall be decided in accordance with the Indian Standards based on the findings of the detailed soil investigation to be carried out by the contractor. High Alumina cement shall NOT be used.

Delivery and storage of cement- Cement shall be delivered to the site in bulk or in sound and properly sealed bags and while being loaded or unloaded whether conveyed in vehicles or by mechanical means, and during transit to the concrete mixers, must be protected from the weather by effective coverings. Efficient screens are to be supplied and erected to prevent wastage of cement during strong winds. If the cement is delivered in bulk, the Contractor shall provide at his own cost approved silos of adequate size and number to store sufficient cement to ensure continuity of work. The cement shall be placed in these silos immediately it has been delivered on the site. Suitable precautions shall be taken during unloading to ensure that the resulting dust does not constitute a nuisance.

If the cement is delivered in bags, the Contractor shall provide at his own cost perfectly waterproof and well-ventilated sheds having a floor of wood or concrete raised at least 150 mm above the ground. The sheds shall be large enough to store sufficient cement to ensure continuity of work. Each consignment of each type of cement shall be stacked separately therein. On delivery at site the cement shall at once placed in these sheds and shall be used in the order in which it has been delivered. Only fresh cement shall be used for all concrete.

c) Aggregate

Coarse and fine aggregate shall conform to the requirements of IS 383-1970.

Sampling and testing of aggregates shall be in accordance with the relevant Indian Standard.

Fine and coarse aggregates shall be obtained from the same source and the Contractor shall ensure that material from the source is known to have a good service record over a long period of time.

Aggregate shall be hard and dense and free from earth, clay, loam and soft, clayey, shaley or decomposed stone, organic matter and other impurities.

d) Storage of aggregates

Coarse and fine aggregates shall be stored on site in bins or on clean, dry, hard surfaces, and be kept free from all sources of contamination. Aggregates of different gradings shall be stored separately, and no new aggregate shall be mixed with existing stocks until tested and approved by EMPLOYER.

e) Approval of Supplies

As soon as possible after the Contract has been placed the Contractor shall submit a list giving details of the sources from which he proposes to obtain concrete and mortar materials. Only materials from approved sources shall be brought to site, but EMPLOYER will be prepared to extend his approval to other satisfactory sources of supply which may be proposed by the Contractor. Approval of a source of supply shall not imply acceptance of material found not to conform to this Specification

f) Water

Water used for mixing concrete and mortar shall be clean, fresh water obtained from an approved source and free from harmful chemicals, oils, organic matter and other impurities. Normally potable water may be considered satisfactorily for mixing and curing concrete and masonry work. Requisite tests to be done if directed by Employer.

g) *Steel bar reinforcement (Fe500)*

Reinforcement shall be of Fe-500 corrosion resistant steel bar complying to the appropriate Indian Standards from Primary Producer e.g TATA Steel, SAIL, Jindal, RINL, as per IS 13620:1993 or latest version. All bar reinforcement shall be hot rolled steel except where the use of cold worked steel is specified on the drawings or otherwise approved.The bars shall be round and free from corrosion, cracks, surface flaws, laminations, rough, jagged and imperfect edges and other defects.The bar reinforcement shall be new, clean and of the lengths and diameters described on the Drawings and Schedules. Bars shall be transported and stored so that they remain clean, straight, undamaged and free from corrosion, rust or scale. Bars of different diameters shall be separately bundled.

i) Bending of reinforcement

All steel bars are to be accurately bent cold to the shapes and sizes indicated on the Drawings and Schedules unless otherwise approved. Re-bending of bars and bending in position in the works shall not generally be allowed.

ii) Welding of reinforcement

Spot or tack welding for positioning bars in heavily reinforced areas will only be allowed with the express permission of EMPLOYER. Extension of lengths of reinforcement by welding will not be permitted. Welding will be approved only in low stress members, and lap welding will not be approved in any circumstances.

iii) Fixing of reinforcement

Before fixing in the works bars shall be seen to be free from pitting, mud, oil, paint, loose rust or scale or other adherents harmful to the bond or strength of the reinforcement. Bars shall be fixed rigidly and accurately in position in accordance with the working drawings, unless otherwise approved by EMPLOYER. Reinforcement at all intersections shall be securely tied together with 1.5 mm soft annealed tying wire the ends of which shall be cut and bent inwards. Cover to the reinforcement shall be in accordance with Clause 15.12 of this specification and sufficient spacers and chairs of precast concrete of approved design shall be provided to maintain the specified cover and position. No insertion of bars in previously placed concrete shall be permitted. Projecting bars shall be adequately protected from displacement. The fixing of reinforcement in the works shall be approved by EMPLOYER before concrete is placed. Measurement will be based on the calculated weights of steel actually used in tonnes corrected to second place of decimal.

iv) Concrete cover to reinforcement

For durability the minimum concrete cover to any reinforcing bar shall be as follows:

Concrete above ground.

- Internal faces of slabs 25 mm
- Internal faces of beams and walls 30 mm
- Exposed faces of slabs, beams and walls 50 mm
- All faces of columns and sub-structures 50 mm

Only concrete or steel spacers shall be used to achieve the required minimum thickness of concrete cover to reinforcement. Concrete spacers shall have nonmetallic ties. Timber blocks for wedging the steel off the formwork will not be allowed.

h) Formwork

Form work shall be constructed from 12mm thick wáter proof Plywood Board (30kg) as necessary for special finishes and designed with the quality and strength required to ensure rigidity throughout placing, ramming, vibration and setting of the concrete, without detrimental effect. Form work shall be erected true to line, level and shapes required using a minimum of approved internal ties. Faces in contact with the concrete shall be true and free from defect, jointed to prevent loss of water or fines, in panels or units which permit easy handling, and designed to permit side forms to be struck independently of soffit shuttering. Ties or spaces remaining embedded shall have the minimum cover specified for reinforcement.

Forms for exposed concrete beams, girder casings and columns shall provide for a twenty-five millimetre chamfer on external corners. Wedges and clamps shall be kept tight during vibration operations. Before commencement or resumption of concreting, the interior of forms shall be cleaned and free of sawdust, shavings, dust, mud or other debris and openings shall be formed to facilitate this cleaning and inspection. The inside of the forms shall be treated with a coating of an approved substance to prevent adhesion. Care shall be taken to prevent this substance being in contact with the reinforcement.

i) Grades of concrete

Concrete shall be either ordinary or controlled and in grades designated M10, M15, M20 and M25 as specified in IS 456 (latest edition). In addition, nominal mixes of 1:3: 6 or as indicated on drawings, or any other mix without any strength requirements as per mix design shall be used where specified. RCC for pile works shall be Design Mix of minimum grade M-25 and also minimum cement content shall be 400 kg/cum as per IS:2911.

i) Ordinary concrete

Ordinary concrete shall be used for all plain cement concrete (PCC) work and where shown on drawings in proportioning concrete, the minimum quantity of cement shall be as specified in Table 15.15.1 of this clause and the amount to be used shall be determined by actual weight. The quantities of fine and coarse aggregate may be determined by volume, but preferably by weight.

The water cement ratio shall not be more than those specified in IS 456.
or allowed by EMPLOYER. Ordinary concrete shall not require preparation of trial mixes.

Grade of Concrete	Minimum
M10	236 kg
M15	323 kg
M20	410 kg
M25	530 kg

ii) Controlled concrete

i. Mix proportions

The mix proportions for all grades of concrete shall be designed to obtain strength corresponding to the values specified in IS 456 for respective grade of concrete. Preliminary tests as specified in the IS Code with 9 nos of cube which is 3 sets of cubes for 7, 14 & 28 days compressive strength has to be verified or as required by EMPLOYER, shall be carried out, sufficiently ahead of the actual commencement of the work, with different grades of concrete made from representative samples of aggregate and cement expected to be used on the job. The purpose of this test is to ascertain the water cement ratio required to produce a concrete having specified strength, and to demonstrate sufficient workability to enable it to be well consolidated and to be worked into corners of shuttering and around the reinforcement.

ii. Mix design

As a guide to perform the mix design properly, the relationship between water cement ratio, aggregate to cement ratio, workability and strength of concrete will be as per relevant IS.

The cement /total aggregate ratio is not to be increased beyond 1: 9.0 without specific permission of EMPLOYER. It should be noted that such high aggregate/cement ratios will be required for concretes of very low slump and high-water cement ratios which may be required to be used in mass concrete work only.

The actual cement aggregate ratios are to be worked out from the specific gravities of coarse aggregates and sand being used, and from trial mixes.

2. **Strength Requirements**

The mix proportions for all grades of concrete shall be designed to produce the grade of concrete having the required workability and a characteristic strength not less than the value given table.

Grade Designation	Characteristic Compressive Strength at 28 days
10	10N / sq. mm
15	15N / sq. mm
20	20N / sq. mm
25	25N / sq. mm

The strength of concrete given above is the 28 days characteristic compressive strength of 15 cm cube.

ii) Target mean strength of concrete

The target mean strength of concrete shall be as per IS 456:2000 or CPWD specifications and the formula governing thereto

j) Workability

The workability of concrete shall be checked at frequent intervals by slump test, where facilities exist and if required by EMPLOYER, alternatively the compaction factor test in accordance with IS 1199 shall be carried out.

k) Mixing of Concrete

Unless otherwise approved, concrete for foundations will be M 20 grade, corresponding to nominal mix of 1:1.5:3 as per IS 456. The proportions of fine and coarse aggregate, cement and water shall be as determined by the mix design or according to fixed proportions in case of nominal mix concrete and shall always be approved by EMPLOYER. The quantities of the cement, fine and coarse aggregates shall be determined by weight, the water shall be measured accurately after giving proper allowance for surface water present in the aggregate. Water shall be added to make a workable mix and it is important to maintain the water-cement ratio at its maximum value of 0.55 in accordance with the requirements of IS 456.

Water shall not be added to the mix until all the cement and aggregates constituting the batch are already in the drum and dry mix for at least one minute. Mixing of each batch shall be continued until there is uniform distribution of materials and the mass done for less than 2 minutes and at least 40 revolutions after all the materials and water are in the drum.

When hand mixing is permitted by EMPLOYER for concrete to be used in unimportant locations it shall be carried out on a watertight platform and care shall be taken to ensure that mixing is continued until the mass is uniform in colour and consistency. In case of hand mixing, an extra 10% of cement shall be added to each batch and additional cost due to extra cement will be borne by the Contractor.

l) Conveying Concrete

Concrete shall be handled and conveyed from the place of mixing to the place of final laying as rapidly as practicable by approved means before the initial setting cement starts. Concrete should be conveyed in such a way which will prevent segregation or loss of any of the ingredients. If segregation does occur during the transport of concrete same shall be re- mixed. The requirements to be fulfilled during transportation are:

No segregation or separation of materials in the concrete, and concrete delivered at the point of placing should be uniform and of proper consistency.

m) Placing Concrete

Form work and reinforcement shall be approved in writing by EMPLOYER before concrete is placed. The forms shall be well wetted and all shavings, dirt and water that may have collected at the bottom shall be removed before concrete is placed. Concrete shall be deposited in its final position without segregation, re-handling or flowing. As far as possible concrete shall be placed in the formwork by means approved by EMPLOYER and shall not be dropped from a height or handled in a manner which may cause segregation. Any drop over 180 cm. shall have to be approved by EMPLOYER. Once the concrete is deposited in its final position, it shall not be disturbed. Care should be taken to avoid displacement of reinforcement or movement of formwork.

The placing of concrete shall be a continuous operation with no interruption in excess of 30 minutes between the placing of continuous portions of concrete. When fresh concrete is required to be placed on previously placed and hardened concrete, special care should be taken to clean the surface of all foreign matter. For securing a good bond and water tight joint, the receiving surface should be made rough and a rich mortar placed on it unless it has been poured just before. The mortar layer should be about 15 mm thick with cement and sand proportion as that of the mix in use, and have the same water-cement ratio as the concrete to be placed.

After the concrete has been placed it shall be thoroughly compacted by approved mechanical vibration to a maximum subsidence without segregation and thoroughly worked around reinforcement or other embedded fixtures into the correct form and shape. Vibrators must be operated by experienced men and over vibration shall not be permitted. Care should be taken to ensure that the inserts, fixtures, reinforcement and formwork are not displaced or disturbed during placing of concrete. No concrete shall be placed in open while it rains. If there is any sign of washing of cement and sand, the concrete shall be entirely removed immediately. Slabs, beams and similar structure shall be poured in one operation normally. In special circumstances with the approval of Authorized representative of EMPLOYER these can be poured in horizontal layers not exceeding 50 cm. in depth. When poured in layers, it must be ensured that the under layer is not hardened. Bleeding of under layer if any shall be effectively removed.

n) Compaction of Concrete

Compaction is necessary for production of good concrete. After the concrete has been placed it shall be thoroughly compacted by approved mechanical vibrator to a maximum subsidence without segregation and thoroughly worked around reinforcement or other embedded fixtures into the correct form and shape. Vibrators must be operated by experienced men. Care should be taken to ensure that the inserts, fixtures, reinforcement and formwork are not displaced or disturbed during the vibration of the concrete. The Contractors shall provide standby vibrators. Vibration is commonly used method of compaction of concrete, the use of mechanical vibrators complying with IS 2505, IS 2506, IS 2514 and IS 4656 for compacting concrete is recommended

For all practical purposes, the vibration can be considered to be sufficient when the air bubbles cease to appear and sufficient mortar appears to close the surface and facilitate easy finishing operations. The period of vibration required for a mix depends upon the workability of the mix.

o) Curing of Concrete

In order to achieve proper and complete strength of the concrete, the loss of water from evaporation should be prevented. percent of the strength is attained in the first 28 days and hence this 28-day strength is considered to be the criterion for the design and is called characteristic strength. The concrete after setting for 24 hours shall be cured by keeping the concrete wet continuously for a period of 10 days after laying.

The curing increases compressive strength, improves durability, impermeability and abrasion resistance. Failure to carry out satisfactory curing can lead to cracking in the concrete. This in turn can lead to salt attack of the reinforcement and consequential failure of the structure. If cracks occur in a structure which are severe enough to affect the structure, the Contractor shall cut out and replace the defective concrete at his own cost. The Contractor’s attention is, therefore, drawn to this particular aspect of proper and adequate curing.

p) Construction joints

Construction joints are a potential source of weakness and should be located and formed with care and their number is kept to a minimum. When the work is to be interrupted, the concrete shall be rebated at the joint to such shape and size as may be required by EMPLOYER or as shown on the drawings. All vertical construction joints shall be made with water bars which are rigidly fixed and shall provide a positive barrier against movement of water through the joint. Great care shall be taken when placing concrete around water bars because the space is often congested. Concreting shall be carried out continuously up to construction joints. Construction joints, if not described on the drawings, shall be in accordance with the following:

- In a column, the joint shall be formed about 75 mm below the lowest sofit of the beams framing into it, at the meeting points of the columns and the raft, and at the point of contraflexure in the columns.
- Concrete in a beam shall be placed throughout without a joint. However, if the provision of a joint is unavoidable, the joint shall be vertical and at the middle of the span.
- A joint in a suspended floor slab shall be vertical at one of the quarter points of the span and at right angle to the principal reinforcement.
- Additional reinforcements and shear keys shall be provided at the construction joints.

In forming a joint, concrete shall not be allowed to slope away to thin edge. The locations of construction joints shall be planned by the contractor well in advance of pouring and be approved by EMPLOYER. Construction joints in foundation of equipment shall not be provided without the approval of Authorized representative of EMPLOYER.

q) Expansion and separation joints

Expansion joints shall be as shown on the drawings or as specified in the schedules. Expansion joint filler boards conforming to IS 1838 and sealing strips shall have minimum transverse joints. Joints shall be vertical and straight except where otherwise approved and concrete surfaces and faces shall be flush on both sides of the joint.

Separation joints shall be with standard waterproof paper or with as alkathene sheets about 1 mm in thickness. Lap length and sealing of laps shall be to the satisfaction of EMPLOYER.

r) Removal of form work

Form work shall be kept in position fully supported, until the concrete has hardened and gained sufficient strength to carry itself and any loads likely to be imposed upon it. Stripping must be affected in such a manner and at such a time that no shock or other injury is caused to the concrete. The responsibility for safe removal rests with the Contractor but EMPLOYER may delay the time of striking if he deems it necessary.

s) Pre cast concrete members

Precast concrete members shall be used in the works only where specified on the Drawings or approved by EMPLOYER. The technical specifications for cement concrete, formwork and reinforcement covered under earlier clauses shall form a part of these specifications and shall be followed for carrying out precast concrete work.

Precast members shall not be disturbed or lifted until the minimum periods specified for formwork removal have elapsed.

t) Load Test on Parts of Structures

The load test on concrete, if desired by EMPLOYER shall be carried as soon as possible after the expiry of 28 days from the time of placing of concrete as per the clause 16.5 to 16.6 of IS: 456.The structure shall be subjected to a load equal to full dead load of the structure plus 1.25 times the imposed load for a period of 24 hours and then the imposed load shall be removed. The entire cost of load testing shall be borne by the contractor and if any portion of the structure found unacceptable under the relevant clause of IS: 456, the same shall be dismantled and replaced by a new structure as per specification at no extra cost to the Employer. If during dismantling any of the adjacent structure is damaged, the same shall be made good free of charge by the contractor to the satisfaction of EMPLOYER.

u) Finish of concrete surface

i. Concrete cast against formwork.

The following finishes to concrete surfaces, unless otherwise specified or shown on the drawings, shall be as follows—

1. **Class A1**: All permanently exposed surfaces, including exposed sides of foundations.
2. **Class A2**: Surfaces to be covered by backfill, plasters or the like.

Class A1 surfaces shall be dense, fair, smooth, even, free from honeycombing, water and air holes and other blemishes, true to line and surface and free from board or panel marking. They shall be of uniform colour. Rendering of defective surfaces shall not be permitted, and, if ordered by EMPLOYER, the Contractor shall at his own expense cut out to expose reinforcement and make good any unsatisfactory work. All areas so treated shall be rubbed down and kept moist for several days.

Class A2 surfaces shall be dense, even, free from honeycombing and true to line and surface.

Any special finishes will be to details or instructions given by EMPLOYER.

ii. Concrete not cast against form work.

The following finishes shall be provided unless otherwise specified or shown on the drawings—

1. **Class B1**: All permanently exposed surfaces, including tops of equipment foundations, wall copings, window sills, precast items (except paving flags).
2. **Class B2**: Paving flags and paths. Floors and slabs to be surfaced with blocks, tiles or waterproofing materials.
3. **Class B3**: Roads, buried concrete and floors or slabs to be covered by screed.

Class B1 surfaces shall first be levelled and screened to produce a true surface. After the moisture film has disappeared, and the concrete has hardened sufficiently, the surface shall be finished with a steel trowel under firm pressure to give a smooth, dense, even and hard surface free from all marks and defects.

Class B2 surfaces shall be levelled and screened to produce a true surface and be finished with wooden or steel float to give a level surface free from screed marks. Excessive floating shall be avoided.

Class B3 surfaces shall be levelled and screened to produce a true and uniform surface.

v) Holes, pockets, threaded inserts, etc.

The threaded inserts for casting into concrete shall be electro-galvanized and of malleable iron or mild steel. Holes, cavities and fixings shall be provided in the works only at the positions indicated on the drawings or as directed and they shall be incorporated as necessary during the work of concreting. Unless otherwise agreed a tolerance in position of plus or minus five millimetres shall be allowed. Inserts and bolts shall be fixed square in the works by means of temporary bolts or nuts, and then concrete cast around them. The projecting portions of such fixings, and concrete within fifty millimetres of them, shall be bitumastic painted and all threads well greased on completion of the work. Holes and pockets shall be stripped down clean on completion.

w) 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 IS:9103. The water proofing cement additives shall conform to IS:2645. Concrete admixtures and additives shall be approved by EMPLOYER.

The Contractor shall use an approved neutralized vinsol resin air-entraining agent in all concrete. The Air entraining agent shall be supplied and batched as a solution with a solids content not exceeding 15 percent by weight with suitable, stable and consistent pH.

The Contractor may propose, and 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 overcoming unusual circumstances and placing conditions.

Water-reducing set-retarding admixture shall be an approved brand of lgno-sulphonate type admixture.

Water proofing cement additives shall be used as required or advised by EMPLOYER.

5.19 INTERFACING

Proper coordination and execution of all interfacing civil works activities such as fixing of conduits in roofs/walls/floors, fixing of foundation bolts, fixing of lighting fixtures, fixing of supports/embodiments, 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 such that dismantling, breakage etc. is reduced to minimum.

5.20 WATER SUPPLY

The Contractor shall be overall responsible for supply of water within switch yard for firefighting, drinking purposes, construction purpose and other miscellaneous purposes. The scope is also inclusive of installation of deep tube well, construction of slow sand filter and ground storage tank, supply and installation of distribution network pipe lines, supply and erection of all overhead tanks, staging for OH tank wherever necessary, pipes, fittings, motors, etc. required for the water supply to be taken from the terminal point to the respective buildings. A scheme shall be prepared by the contractor indicating the layout and details of water supply which shall subject to the approval of EMPLOYER before actual start of work. Any extra bore holes required shall be within the scope of the contractor.

There shall be separate bore wells for the control room building and colony quarters if required. There shall be pump houses for the bore wells and approach road to the pump houses shall be provided. Boring and installation of 250mm dia deep tube with 200mm min dia. PVC casing and 5nos. of filter (3m each) and the gap between boring and casing shall be filled with pea size gravels. Provide 2 HP submersible pump with 40mm dia CPVC column pipe. Pump shall be tied with laminated twin steel wire rope (10sqmm). For service connection provide 6sqmm UG cable and 3 core 6sqmm copper cable shall be provided for control panel etc. including all accessories such as nipple, clamp elbow, well cover, valve etc. to complete the work in all respect.

Provide two storied RCC (M-25) slow sand filter having sand filter at upper level with aeration arrangement and openable steel roof and reserviour at bottom. Bottom reserviour shall be 600mm above FGL with stopper at construction joint, water proofing, 2 HP horizontal submersible pump for delivery to OH tank, outlet and drainage valve, control panel (starter), cable, approved sand for filter media (charcoal, stone chips, etc. as per requirement).

CPVC distribution pipe network from storage tank to all the OH tank of building i.e RE residence, officer’s hoatel, staff’s hostel, transit camp, security booth, security barrack, store building, control room building as well as landscaping work for gardening.

The capacity of each submersible pump shall be 2 HP and all control as per standard has to be provided. The no of bore holes shall be two nos, one for colony township and the other one for the switch yard building. Two nos pump house as per standard are also within the scope of this contract. The height of the pump house (LXW=3mtrsX3mtrs) shall be 3 mtrs and shall have RCC roof and brick walls having MS doors.

Overhead water tank shall be as per BOQ.

There shall be interconnection between two pump sections in order to meet any exigencies.

5.21 SECURITY BOOTH

There shall be one RCC type security booth near the main gate, switchyard gate and as per master plan to be provided as per design and drawing. The booth shall have also provision of sitting arrangement for the guests and toilet. The shed shall be provided with telephone internal, electrical lighting and ceiling fan facilities. There shall be provision of gate lights. A portion of the shed shall be used for the guest who comes for visit the sub-station. Adequate no. of aluminium doors and windows are also to be provided. Necessary paintings as per standard are also to be done.

5.22 CAR PARKING SHED

Shed for Car parking shall be constructed adjacent to all building depending upon the space available and the requirement. Each unit for single car parking shall be of minimum size 5.5m x 3 m with a plinth height of minimum 300 mm. The floor should be completed with pavers block with appropriate base, which has to be joined with the approach or internal road. Shed structure shall be constructed using Steel section by TATA of YST 310 Grade or equivalent with RCC block as base. Shed roofing to be completed with PPGI sheet roofing with minimum 0.6 mm thickness.

(Design and Drawing to be prepared by Contractor and shall be approved by EMPLOYER)

5.23 STATUTORY RULES

The Contractor shall comply with all the applicable statutory rules pertaining to Factories Act (as applicable for ASSAM State), Fire Safety Rules of Tariff Advisory Committee, Water Act for pollution control etc.

Provisions for fire-proof doors, numbers of staircases, fire separation wall, plastering on structural members (in fire prone areas) etc. shall be made according to the recommendations of Tariff Advisory Committee.

Statutory clearance and norms of State Pollution Control Board shall be followed as per Water Act for effluent quality from plant.

5.24 LANDSCAPING, GARDEN & PLANTATION

Within the campus gardening should be done on roadside as well as available spaces. Proper water supply piping should be provided for aeriation. A garden in front of the control room building is to be developed. It includes treatment of the land of size (30mtrsX10mtrs), manuring, and plantations of sufficient flower based, show based, crotons and entire portion shall be provided with garden grass. Proper land slope also to be maintained for better and aesthetic looking. Provision of water taps and garden lights at different locations are to be provided for watering the plants and lighting of the garden. 100 nos. fruit bearing plants and 100 nos. other show plants along the roadside, near colony quarters and near control room building are required to be planted. Treatment of the soil and manuring are to be done before plantation of these plants. Water taps at different locations are to be provided for watering the plants. **Plantation of trees shall comprise of Bakul tree and flowering plant Mosanda, multiple colours of Bougainvillea and Hydrangea.**

5.25 RAINWATER HARVESTING

In addition to drainage of rainwater, the contractor shall make arrangement for rainwater harvesting also.

Rainwater harvesting shall be done by providing two numbers recharge structures with bore wells. The recharge structures shall be suitably located within the S/S. Branch drains from the main drain carrying rainwater from entire switchyard shall be connected to the recharge structures.

The internal diameter of recharge shafts shall be 4.5 meter with 230mm thick lining of brick work up to a depth of 2.0 meter from ground level and 345mm thick brickwork below 2.0-meter depth. The brickwork shall be constructed with cement mortar 1:6 (1 cement: 6 coarse sand). The overall depth of shaft shall be 5.0 meter below invert level of drain. The shaft shall be covered with RCC slab for a live load of 300Kg. per Sq. m. two openings of sizes 0.7X0.7 meter shall be provided in the RCC cover slab as shown in the drawing. An iron cover made of 5mm thick chequered plate with hinges shall be provided in the openings. Galvanized M.S. rungs of 20mm diameter at spacing of 300mm shall be provided in the wall of the shaft below the opening of the RCC slab to facilitate cleaning of shaft.

A 300mm diameter bore well shall be drilled in the center of the shaft. The depth of bore well shall be 5.0 meter more than the depth of the sub soil water.

A 100mm diameter medium duty MS pipe confirming to IS 1161 shall be lowered in the bore well keeping bail plug towards bottom of bore well. The pipe shall have 1.58mm holes for 4.0-meter length starting from 1.0 meter from bottom of bore well. Holes of 3.0mm dia. Shall be provided for a length of 2.0 meter starting from the bottom level of coarse sand and downwards. The overall length of the pipe shall be equal to the total depth of the bore well plus depth of shaft.

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

Fire water Tank: This is a lump-sum item. The contractor shall be required to complete the work in all respect as per requirement. All the items including excavation, compaction, brick work, roof truss, corrugated PPGI Sheet roofing, all types of miscellaneous steel internal and external plastering, painting, etc. shall be deemed to be included in this lump-sum water tank.

CHAPTER 6: AIR CONDITIONING SYSTEM

6.1 HI-Wall Split Air Conditioners

SCOPE

This specification covers the general design, materials, construction features, manufacture, shop inspection and testing at manufacturer's works, delivery at site, handling at site, installation, testing, commissioning, performance testing and handing over of split air-conditioners (SAC).

CODES AND STANDARDS

The design, materials, construction, manufacture, inspection, testing and performance of window air conditioners shall comply with all currently applicable statutes, regulations and safety codes in the locality where the equipment is to be installed. The equipment shall also conform to the latest applicable Indian or equivalent standards. Other international standards are also acceptable, if these are established to be equal or superior to the listed standards. Nothing in this specification shall be construed to relieve the CONTRACTOR of this responsibility.

CONSTRUCTION FEATURES

- **CABINETS**

  The split air-conditioners shall comprise of two components viz. indoor unit (IDU) and condensing/outdoor unit (ODU), interconnected with refrigerant piping. Indoor unit shall house air handling fan, cooling coil, insulated drain tray and filter. The unit shall be of heavy gauge steel, corrosion resistant, finished with synthetic enamel paint and acoustically insulated with resin bonded fiber glass or equivalent material. Suitable drain connection shall be provided for removal of condensate collected inside the drain tray under cooling coil. The front panel shall be decorative type with supply air grille of adjustable type and having adequate return air passage. The front panel shall be made of plastic or aluminium and shall be easily removable for cleaning of filter.

  The unit shall be suitable for wall mounting and can also be ceiling suspended. Condensing/outdoor unit shall house compressor and condenser and shall be of heavy gauge corrosion resistant carbon steel and shall be suitable for mounting in open space (e.g. on terrace or on outside wall).

- **COMPRESSOR**

  The compressor shall be hermetic scroll or rotary and shall be mounted on vibration isolators. Necessary crank case heaters shall be provided. The power supply to the heaters shall be from an auxiliary source so as to keep the power available even while the unit is switched off for routine maintenance.

- **CONDENSER**

  The air-cooled condenser shall be with copper tubes and aluminium fins with low noise fan(s). Speed of axial fan(s) shall not exceed 960 RPM for fan with impeller diameter above 450 mm and 1440 RPM for fan with impeller diameter 450 mm and less. The impeller shall be statically and dynamically balanced. Condenser coil shall have anti-corrosion treatment. The casing of the condensing unit shall be given treatment to withstand harsh weather conditions of the ambient.

- **AIR HANDLING FAN**
  The fan shall be centrifugal type with forward curved impeller. The impeller shall be statically and dynamically balanced. The drive motor shall be directly coupled to the air handling fan.
- **COOLING COIL AND FILTER**

  The cooling coil shall be of direct expansion type with copper tubes and aluminium fins. This shall be minimum three (3) rows deep and with minimum three (3) fins per centimetre. Anti-corrosive coating shall be provided on coil.

- **FILTER**
  The air, before it enters the cooling coil, shall be filtered by dry and cleanable type filters. The filters shall include (either one or more of) anti-dust, deodorization, anti- bacterial and/or ultraviolet types, as Specified.

- **REFRIGERATION PIPING AND CONTROLS**
  The refrigeration piping shall be complete with externally equalized thermostatic expansion valve, liquid line strainer, dehydrator with replaceable drying agent and liquid line shut-off valve.

  Refrigerant piping, fittings and piping joints shall conform to the requirements ANSI B 31.5.

  The piping shall be designed for an internal pressure representing the most severe condition of coincident pressure and temperature expected in normal operation.

  Vacuum testing shall be done for medium vacuum of around 40 mm Hg absolute and held with vacuum pump in operation for at least 4 hours. Thereafter unit shall be sealed and vacuum held for at least 12 hours. Vacuum break shall be done using refrigerant and pressure raised to standing pressure in refrigerant cylinder.

  ON-OFF thermostat with adjustable setting shall be provided for temperature control. A selector switch enabling the running of air handling fan alone or fan with cooling shall be provided. Interlock shall be provided such that compressor can start only after starting air handling fan. Provision shall also be made to interlock the compressor with air cooled condenser fan motor. Safety devices such as high/low refrigerant pressurestat (HP/LP) and compressor oil pressurestat (OP), hermetic motor winding thermostat etc. shall be provided. HP and OP cut out shall be manual reset while LP cut out shall be auto reset type.

  Refrigerant and oil shall be supplied along with the unit. The refrigerant and oil charging shall be carried out at site. Exposed refrigerant piping shall have anti- corrosive coating.

ELECTRICAL

This controller shall facilitate automatic periodic switching of the units from working to standby mode in a predefined sequence so that all the units shall be in operation for a defined period of time. This system shall be required in (N+1) OR (N+2) type combination of working & standby units.
The unit shall be provided with single phase preventers for all motors. Each SAC shall be provided with three pin Plug and cable.

The indoor and outdoor units shall be pre-wired at the factory and shall be complete with starters for all motors.

Wiring between indoor and outdoor units shall be carried out at site.
Cordless remote controller shall be provided. Remote controller shall have ON/OFF & temperature control option.

6.2 LOUVERS

SCOPE

This specification covers the general design, materials, construction features, manufacture, shop inspection and testing at manufacturer's works, delivery at site, handling at site, installation, testing and commissioning at site of louvers required for fresh air intake and exhaust air outlets for air-conditioning and ventilation systems.

CODES AND STANDARDS

The design, materials, manufacture, inspection, testing and commissioning of louvers shall comply with all currently applicable statutes, regulations, codes and standards in the locality where the louvers are to be installed. Nothing in this specification shall be construed to relieve the CONTRACTOR of this responsibility. In particular, the louvers shall conform to the latest edition of following standards:

AMCA 500-L Laboratory Methods of Testing Louvers for Rating

CONSTRUCTION FEATURES

The louvers shall consist of parallel metallic blades. The louvers shall be provided with fixed type blades or adjustable opening type blades.

The width and angle of blades shall be such as to minimize the entry of water and snow inside. The minimum percentage of free area shall be 35% to 37%. The minimum projected width of blades in horizontal plane shall be 150 mm with the blades inclined at minimum 35 degrees. The blades shall be overlapping each other with maximum 30 mm height in vertical plane between two blades. Blades shall be bent back at edges and ridged to provide stiffness and prevent water from travelling up. Width of one bank of louvers shall be 1000 mm maximum. In case width is more, mullions shall be provided to restrict width to less than 1000 mm. For adjustable type louvers, mechanism of blade angle adjustment shall be designed in such a manner that maximum effort required shall not exceed 20 Kgf. The blade linkage rod shall be of cold rolled steel and minimum 8 mm diameter. The number of blade linkage rod shall be one (1) for every 1000 mm width of louvers or part there-of. The louvers shall be located at a minimum 350 mm height above the ground or roof level to minimize the pick-up of dust and the probability of snow piling up and subsequently entering the louver during winter operation. The louvers shall be located in such a manner that cross contamination from other exhaust does not occur. Bird screen of 10 mm^2 and minimum 16 G wire mesh shall be provided on outer face of louvers, wherever the louvers are exposed to atmosphere. The frame of louver shall have a sill extension of 50 mm to provide drip ledge so that rainwater drains outside.

The frame of louver shall have suitable framework for installation of filter and damper.

6.3 HVAC SYSTEM

The ductable AC for Control Panel Room of GIS building shall be of brands fulfilling the following criteria –

1.0 The brand shall have operational experience of minimum 8 years in the Northeast India or Guwahati.
2.0 The brand shall be eligible to sign AMC with AEGCL and they shall currently have AMC in HVAC of minimum 500 ton in the Northeast India or Guwahati.

The brand shall have prior experience in supplying and installation of HVAC to govt. sector or PSU of minimum 1000 ton in the Northeast India or Guwahati.

6(A) Detailed Specifiction of ductible Air Conditioner:

Capacity	≥ 3x20 TR and 3x11 TR
Compressor	Scroll
Circuit	Twin Ckt
Controller Circuit	Microprocessor
Condenser Coil	100% Copper
Condenser Fan	Propeller
Condenser Fins	Copper (Preferable) OR Aluminum coated with Hydrophilic quoting OR higher Spec.
Air Filter	Synthetic type G3, Washable
Indoor Unit	Ceiling suspended
Indoor Fan Type	Centrifugal
Outdoor Unit Cabinet	Galvanized Iron (GI) Sheet Steel Powder Coated (Preferable) OR Quoted with powder based Epoxy Paint.
Fan Drive	Direct
Refrigerant`	R410A
Remote	Yes
Power supply	3 Phase, 50Hz
Features	*Auto Switch ON or Switch OFF in case of multi Compressor to suit part load and save power. *Memory backup of setting under power failures. *Auto Restart after Power failure. *Run time equalization of the Compressor. * Built in Time Delay to protect Compressor from instant Start/Restart. *Fault Diagnostics
Safety Controls	*HP/LP to protect the compressor from High & Low Pressure * Protection for Low voltage, Single Phase and Phase reverse *In-built Thermal/Temperature protection

Charges towards Complete Installation with Followings:	*Transport Charges if any. *Commissioning includes pressure testing / Vacuuming etc. **Refrigerant piping (Copper)** ***Copper flexible power cabling laid in 1“ PVC pipe with clamping.** *Fabrication of outdoor mounting stand with MS angle powder coated. *Modification of ducting with canvas connection:

CHAPTER 7: GENERAL TECHNICAL CLAUSES FOR DESIGN

7.1.1 GENERAL

The following provisions shall supplement all the detailed technical specifications and requirements brought out in accompanying Technical Specifications. The Contractor's proposal shall be based upon the use of equipment and materials complying fully with the requirements specified herein. It is recognized that the Contractor may have standardized on the use of certain components, materials, processes or procedures different to those specified herein. Alternate proposals offering similar equipment based on the manufacturers standard practice will also be considered, provided such proposals meet the specified design standard and performance requirement and are acceptable to AEGCL.

SYSTEM PARAMETERS

S. No.	Description of Parameters	400 KV System	220 KV System	132 KV System	33 KV System
1.	System Operating Voltage	400 KV	220 KV	132 KV	33 KV
2.	Maximum operating voltage of the system (rms)	420 KV	245 KV	145 KV	36 KV
3.	Rated Frequency	50 Hz	50 Hz	50 Hz	50 Hz
4.	No. of phase	3	3	3	3
5.	Rated Insulation levels				
i	Full wave impulse withstand voltage (1.2/50 microsecs.)	1425 kVP	1050kVP	650 kVP	250 kVP / 170 kVP
ii	Switching impulse withstand voltage (250/ 2500 micro sec.) dry and wet	1050kVP	-	-	-
iii	One-minute power frequency dry / wet withstand voltage (rms)	650 KV / 520 KV	460 KV	275 KV	95 KV/ 70 KV
6	Corona extinction voltage	320 KV	156 KV	105 KV	-
7	Max. radio interference voltage for frequency between 0.5 MHz & 2 MHz at 508	1000 microvolt	1000 microvolt	500 microvolt	

	kV rms for 765 kV, 320 kV rms for 400 KV system, 156 KV rms for 220 KV system & 92 KV rms for 132 KV system				
8	Minimum creepage distance @ 31 mm/KV	13020 mm	7595 mm	4495 mm	1116 mm
9	Min. Clearances				
I	Phase to spacing for installation	7000 mm	4500 mm	3000 mm	1500 mm
Ii	Ground clearances from lowest live terminal of equipment from ground level	8200 mm	7000 mm	5000 mm	4000 mm
10	Rated short circuit current /for three sec. duration	63 KA for 3 seconds	50 KA for 3 seconds	40 KA for 3 seconds	31.5 KA for 3 second
11	System Neutral earthing	Effectively Earthed	Effectively Earthed	Effectively Earthed	Effectively Earthed

7.2 DESIGN AND STANDARDISATION

The Works covered by the specification shall be designed, manufactured, built, tested and commissioned in accordance with the Act, Rules, Laws and Regulations of India. The Equipment(s) shall also conform to the requirements detailed in the referred standards, which shall form an integral part of the Specification, in addition to meeting the specific requirements called for elsewhere in the Specification. The Contract works shall be designed to facilitate inspection, cleaning and repairs, and for operation where continuity of supply is the first consideration. Apparatus shall be designed to ensure satisfactory operation in all atmospheric conditions prevailing at the Site(s) and during such sudden variation of load and voltage as may be met with under working conditions on the system, including those due to faulty synchronizing and short circuit.

The design shall incorporate all reasonable precautions and provisions for the safety of those concerned in the operation and maintenance of the Contract Works and of associated works supplied under other contracts.

Where the Specification does not contain characteristics with reference to workmanship, equipment, materials and components of the covered equipment, it is understood 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.

In case where the equipment, materials or components are indicated in the specification as 'similar' to any special standard, AEGCL shall decide upon the question of similarity. When required by the Specification; or when required by AEGCL the Contractor shall submit, for approval, all the information concerning 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.

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 expense. Each component shall be designed to be consistent with its duty and suitable factors of safety, subject to mutual agreements and shall be used throughout the design. All joints and fastenings shall be so devised, constructed and documented that the component parts shall be accurately positioned and restrained to fulfil their required function.

All outdoor apparatus and fittings shall be designed so that water cannot collect at any point. Grease lubricators shall be fitted with nipples and where necessary for accessibility, the nipples shall be placed at the end of extension piping.

All water and oil pipe flanges shall be to IS 6392/BS 4504 or other equivalent standard, as regards both dimensions and drilling, unless otherwise approved.

Cast iron shall not be used for chambers of oil filled apparatus or for any part of the equipment which is in tension or subject to impact stresses.

Kiosks, cubicles and similar enclosed compartments shall be adequately ventilated to restrict condensation. All contractor or relay coils and other parts shall be suitably protected against corrosion.

All apparatus shall be designed to obviate the risk of accidental short circuit due to animals, birds, insects, mites, rodents or micro-organisms.

Corresponding parts shall be interchangeable. Where required by AEGCL the Contractor shall demonstrate this quality.

7.3 QUALITY ASSURANCE

7.3.1 General

To ensure that the supply and services under the scope of this Contract, whether manufactured or performed within the Contractor’s works or at his Sub-Contractor’s premises or at Site or at any other place of work are in accordance with the Specification, with the Regulations and with relevant Indian or otherwise Authorised Standards the Contractor shall adopt suitable Quality Assurance Programmes and Procedures to ensure that all activities are being controlled as necessary.

The quality assurance arrangements shall conform to the relevant requirements of ISO 9001 or ISO 9002 as appropriate.

The systems and procedures which the Contractor will use to ensure that the Works comply with the Contract requirements shall be defined in the Contractor’s Quality Plan for the Works.

The Contractor shall operate systems which implement the following:

Hold Point “A stage in the material procurement or workmanship process beyond which work shall not proceed without the documented approval of designated individuals or organisations.”

AEGCL written approval is required to authorise work to progress beyond the Hold Points indicated in approved Quality Plans.

Notification Point “A stage in material procurement or workmanship process for which advance notice of the activity is required to facilitate witness.”

If AEGCL does not attend after receiving documented notification in accordance with the agreed procedures and with the correct period of notice, then work may proceed.

7.3.2. Quality assurance programme

Unless the Contractor's Quality Assurance System has been audited and approved by AEGCL, a Quality Assurance Program for the Works shall be submitted to AEGCL for approval a minimum of one month prior to commencement of the works, or such other period as shall be agreed upon by AEGCL. The Quality Assurance Program shall give a description of the Quality System for the Works and shall, unless advised otherwise, include details of the following:

- The structure of the Contractor's organisation
- The duties and responsibilities assigned to staff ensuring quality of work
- The system for purchasing, taking delivery and verification of materials
- The system for ensuring quality of workmanship
- The system for the control of documentation
- The system for the retention of records
- The arrangements for the Contractor's internal auditing
- A list of the administration and work procedures required to achieve and verify the Contract's Quality requirements. These procedures shall be made readily available to AEGCL for inspection on request.

7.3.3. Quality plans

The Contractor shall draw up for each section of the work Quality Plans which shall be submitted to AEGCL for approval at least two weeks prior to commencement of the particular section. Each Quality Plan shall set out the activities in a logical sequence and, unless advised otherwise, shall include the following:

- An outline of the proposed work and program sequence
- The structure of the Contractor's organisation for the Contract
- The duties and responsibilities assigned to staff ensuring quality of work for Contract
- Hold and Notification points
- Submission of engineering documents required by the Specification
- The inspection of materials and components on receipt
- Reference to the Contractor's work procedures appropriate to each activity
- Inspection during fabrication/construction
- Final inspection and test

7.3.4. Inspection and testing

The prime responsibility for inspection and testing rests with the Contractor. The inspection or its waiver by AEGCL does not relieve the Contractor of any obligations or responsibilities to carry out the work in accordance with the Contract.

The inspection and testing shall be documented such that it is possible to verify that it was performed. Records of inspection shall include as a minimum the contract identity, operation/inspection, technique used, acceptance standard, acceptability, identity of inspector/tester and date of inspection/test.

7.3.5. Non-conforming product

The Contractor shall retain responsibility for the disposition of non-conforming items.

7.3.6. Monitoring of quality arrangements

During the course of the Contract AEGCL may monitor the implementation of the Quality Assurance arrangements. Monitoring will be by surveillance of the activities at work locations and/or by formal audits of the adherence of the Contractor to the systems and procedures which constitute his Quality Assurance arrangements. Corrective actions shall be agreed and implemented in respect of any deficiencies.

The Contractor shall provide any facilities, including access, which may be required by AEGCL for monitoring activities.

AEGCL may participate on an agreed basis in the Contractor's monitoring of a sub- contractor's Quality Assurance arrangements.

7.3.7. Method statement

Prior to commencing work, the Contractor shall submit a method statement setting out full details of his method of working. This is a Hold Point.

Details of the Contractor's method of working shall also be submitted at the time of Bidding.

7.4. HEALTH, SAFETY AND ENVIRONMENT (HSE) PLAN

7.4.1 General

7.4.1 General

The contractor/subcontractor should adhere to the Environmental and Social Management Plan (ESMP).

The payment is linked towards compliance to responsibility specified under the generic ESMP attached as Annexure-B (Table-1: ESMP and Table-2: ESMoP) of Volume-II. The contractor should also have to prepare a Contractor's ESMP (CESMP) after signing of the contract and obtain approval from AEGCL prior to commencement of any civil/construction works. The overall responsibility for compliance of ESMP and CESMP will stand with the Project Manager with support of Environmental, Social, Health & Safety Officer (EHSO) and Community Consultation Officer.

The overall responsibility for compliance of ESMP will stand with the Project Manager with support of Health and safety Specialist. The contractor is abided to comply with the project specific ESMP which can be issued by AEGCL to contractor during the complete tenure of project.

Within one month of award of contract the Contractor shall produce a HSE Plan for the contract and submit for the approval of AEGCL. The HSE Plan is described in the following sections. The same is to submit to CGM (PP&D) and ESIA Consultant for approval.

The primary objective of the HSE Plan is for the contractor to demonstrate that he has the capability to carry out the contract work in a cost effective manner, giving due consideration to the Health, Safety and Environmental and Social management of both his own employees, those of the Employer and anyone who may be affected by his activities and in full compliance with the ESMP.

Special arrangements shall be made to accommodate for gender-inclusive engagements and participation of vulnerable people, to ensure the implementation of the social development and gender relevant features included in the design of the project, including monitoring of occupational and community health and safety, community awareness activities, compliance of core labour standards, prevention of Gender-based violence (GBV) and Sexual exploitation (SE) risks.

7.4.2. Content of HSE Plan

The general structure of the HSE Plan is outlined in 7.4.3. The HSE Plan will comprise two parts i.e.:

Part: I: Sections 1 to 5, covering general HSE management and controls. The following would be attached as appendices, where appropriate:

- Organisation chart showing the proposed Contractors HSE organisational structure
- The CV‟s, duties and responsibilities of the following personnel:
  - (i) Contract Manager
  - (ii) Contractors Site Representatives
  - (iii) Environment, Social, Health and Safety Officer
  - (iv) Site Environment, Social, Health and Safety Officers

Part: II: Section 6, providing a summary of hazards and controls.

7.4.3. General structure of HSE Plan

The HSE Plan shall conform to the following general structure:

1. Contractors Policy Statement
2. Health
   - 2.1 First Aid
   - 2.2 Primary health care
   - 2.3 Occupational and community health
3. Safety
   - 3.1 Objectives and targets
   - 3.2 Organisation and responsibilities
   - 3.3 HSE meetings
   - 3.4 Motivation, communication and community awareness.
   - 3.5 HSE training
   - 3.6 Audits and inspections
   - 3.7 Emergency response
   - 3.8 Safety function
   - 3.9 Accident investigating and reporting
   - 3.10 Standards
   - 3.11 Personal protective equipment

4 Environment
   - 4.1 Waste management
   - 4.2 Chemicals management
   - 4.3 Environmental impacts on Air, Noise, and Waterbody
   - 4.4 Fuels and Hazardous Substances Management
   - 4.5 Water Resources Management
   - 4.6 Drainage Management
   - 4.7 Soil Quality Management
   - 4.8 Topography and Landscaping
   - 4.9 Borrow Areas Management
   - 4.10 Protection of Flora and Fauna
   - 4.11 Protection of Fisheries
   - 4.12 Construction Camp Management, including GBV and SE risk prevention measures
   - 4.13 Cultural, Religious Issues, Chance find procedures
   - 4.14 Critical areas
   - 4.15 Subcontractors
   - 4.16 Summary of hazards and controls

7.4.4 Section 6 of HSE Plan

In addition to general hazards and their controls, the following hazards have been identified as specific to this contract and therefore the contractor should demonstrate that he is capable of providing the necessary controls for the work:

- Working within a Permit to Work system
- Working adjacent to live high voltage equipment
- Working adjacent to, and in the vicinity of, live high voltage overhead lines
- Working at elevation
- Lifting operations
- Use of explosives
- Use of heavy machinery including cranage, pile rigs and concrete mixers
- Excavation works
- Work in confined spaces
- Working with insulating oil
- Working with compressed gas
- Rotating machinery

The Contractor should demonstrate his understanding of these hazards by either proposing specific controls for each of them or by giving supporting documentation which demonstrates that such controls already exist.

7.5 PROGRESS REPORTING

The Contractor shall submit for approval, within four weeks of the issue of letter of award, an outline of the design, engineering, material procurement, production, site mobilisation, man and machine deployment, delivery, erection, testing, commissioning, and handing over programme as mentioned earlier. Within a further period of 4 weeks the Contractor shall provide a detailed programme scheduling the future activities in the form of Bar chart and/or any other form to be agreed upon by AEGCL. The Contractor shall submit monthly progress reports to AEGCL office not later than the fifth day of the following month. The reports shall show clearly and accurately the position of all activities associated with design, material procurement, manufacture, works tests, shipping, site erection, testing and commissioning with regard to the agreed contract programme. In addition to the routine monthly progress report the Contractor shall also submit to AEGCL by the 25th day of every month, a man hour schedule for the following month, detailing the man hours scheduled for that month, skill-wise and area-wise. The preferred format for presentation of programmes is MS Project version 4.0 or any latest. The programmes and monthly updates shall be submitted on Email/CD/Hard copy. The design aspect of the progress report shall include a comprehensive statement on drawing and calculations submitted for approval. The position on material procurement shall give the date and details of orders placed and indicate the delivery date quoted by the manufacturer. If any delivery date has an adverse effect on the contract programme the Contractor shall state the remedial action taken to ensure that delays do not occur. The position on manufacture shall indicate the arrival of material, the progress of manufacture and date at which the equipment will be ready for transport. Any events that may adversely affect completion in the manufacturer's works shall also be reported. All works, tests executed shall be listed and the test-results shall be remarked upon. Any test failures shall be highlighted, and the Contractor shall detail the necessary steps taken in order to avoid any adverse effect on the contract completion dates. The despatch of each order shall be monitored on the progress report giving the date by which the equipment will be available for transport, the estimated time of arrival on site and the dates actually achieved.

The site works shall be segregated into civil, mechanical and electrical works for reporting purposes and each section of the site works shall be monitored giving the percentage completion and the estimated completion date in accordance with the contract programme. The number of men working on site, both labour and supervisory staff, shall be reported together with any incidents or events that may affect the progress of site works.

Any delays which may affect any milestone or final completion dates shall be detailed by the Contractor who shall state the action taken to effect contract completion in accordance with the contract programme.

The contractor shall provide two copies of the progress report to AEGCL office. All other activities listed in other sections of bid document also shall be provided.

7.6. STANDARDS

Except where otherwise specified or implied, the Contract Works shall comply with the latest edition of the relevant Indian Standards, International Electro technical Commission (IEC) standards and any other standards mentioned in this Specification. The Contractor may submit for approval, equipment or materials conforming to technically equivalent National Standards. In such cases copies of the relevant Standards or part thereof, in the English language shall be submitted with the Tender. In case of conflict the order of precedence shall be (1) IEC, (2) IS and (3) other alternative standard.

The supply and erection requirements and procedures to be followed during the installation of the equipment shall be in accordance with the relevant Indian/International Standards/Regulations, ASME codes, accepted good engineering practice, drawings and other applicable Indian codes and laws and regulations.

Reference to a particular standard or recommendation in this Specification does not relieve the Contractor of the necessity of providing the Contract Works complying with other relevant standards or recommendations.

The list of standards provided in the Chapter 1 of this Specification is not to be considered exhaustive and the Contractor shall ensure that equipment supplied under this contract meets the requirements of the relevant standard whether or not it is mentioned therein.

7.7. LANGUAGE AND SYSTEM OF UNITS

The English language shall be used in all written communications between the Employers, AEGCL and the Contractor with respect to the services to be rendered and with respect to all documents and drawings procured or prepared by the Contractor pertaining to the work, unless otherwise agreed by the Employer.

It is required that danger plates, equipment designation labels or plates, instruction notices on plant and general substation notices be written in English. Control switch and lamp labels, indicator lamp and annunciator inscriptions shall be in English only.

The design features of all equipment shall be based on the SI system of units.

7.8. MASS AND SIZE OF PARTS AND QUANTITIES OF OIL

The mass and dimensions of any item of equipment shall not exceed the figures stated in the Schedules.

Each item shall be labelled to indicate its mass, quantity of oil (if any) and any special handling instructions.

7.9. GENERAL REQUIREMENTS

7.9.1 Bolts and nuts

All bolts, studs, screw threads, pipe threads, bolt heads and nuts shall comply with the appropriate national standards for metric threads, or the technical equivalent.

Except for small wiring, current carrying terminal bolts or studs, for mechanical reasons, shall not be less than 6 mm in diameter.

All nuts and pins shall be adequately locked.

Wherever possible bolts shall be fitted in such a manner that in the event of failure of locking resulting in the nuts working loose and falling off, the bolt will remain in position.

All bolts, nuts and washers placed in outdoor positions shall be treated to prevent corrosion, by hot dip galvanising or electro galvanising to service condition 4. Appropriate precautions shall be taken to prevent electrolytic action between dissimilar metals.

Where bolts are used on external horizontal surfaces where water can collect, methods of preventing the ingress of moisture to the threads shall be provided.

Each bolt or stud shall project at least one thread but not more than three threads through its nut, except when otherwise approved for terminal board studs or relay stems. If bolts and nuts are placed so that they are inaccessible by means of ordinary spanners, special spanners shall be provided.

The length of the screwed portion of the bolts shall be such that no screw thread may form part of a shear plane between members.

Taper washers shall be provided where necessary.

Protective washers of suitable material shall be provided front and back on the securing screws.

7.10 Galvanising.

7.10.1. General

All machining, drilling, welding, engraving, scribing or other manufacturing activities which would damage the final surface treatment shall be completed before the specified surface treatment is carried out.

7.10.2. Galvanising

All metal surfaces shall be subjected to treatment for anti-corrosion protection. All ferrous surfaces for external use shall be hot dip galvanised. High tensile steel nuts, bolts and spring washers shall be electro galvanised to service condition 4. All steel conductors including those used for earthing and grounding (above ground level) shall also be galvanised according to IS 2629.

All galvanising shall be applied by the hot dip process and shall comply with IS 2629, IS 2633, IS 4759, IS 1367 or IS 6745.

All welds shall be de-scaled, all machining carried out and all parts shall be adequately cleaned prior to galvanising. The preparation for galvanising and the galvanising itself shall not adversely affect the mechanical properties of the coated material.

The threads of all galvanised bolts and screwed rods shall be cleared of spelter by spinning or brushing. A die shall not be used for cleaning the threads unless specially approved by AEGCL. All nuts shall be galvanised with the exception of the threads which shall be oiled. Surfaces which are in contact with oil shall not be galvanised or cadmium plated.

Partial immersion of the work will not be permitted, and the galvanising tank must therefore be sufficiently large to permit galvanising to be carried out by one immersion.

Galvanising of wires shall be applied by the hot dip process and shall meet the requirements of IS 2141.

The minimum weight of the zinc coating shall be 610 gm/sq. m. and minimum thickness of coating shall be 86 microns for all items thicker than 5 mm. For items of less than 5 mm thickness requirement of coating thickness shall be as per BS 729. For surface which shall be embedded in concrete, the zinc coating shall be a minimum of 800 gm/sq. m.

The galvanised 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 such as discoloured patches, bare spots, unevenness of coating, spelter which is loosely attached to the steel globules, spiky deposits, blistered surface, flaking or peeling off, etc. The presence of any of these defects noticed on visual or microscopic inspection shall render the material liable to rejection.

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

The galvanised steel shall be subjected to six one minute dips in copper sulphate solution as per IS 2633.

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 galvanising tests should essentially be performed as per relevant Indian Standards.

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

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

7.11. Cleaning, painting and topicalization

7.11.1. General

All paints shall be applied in strict accordance with the paint manufacturer’s instructions.

All painting shall be carried out on dry and clean surfaces and under suitable atmospheric and other conditions in accordance with the paint manufacturer’s recommendations.

An alternative method of coating equipment such as with epoxy resin-based coating powders will be permitted, subject to the approval of AEGCL, and such powders shall comply with the requirements of IEC 455. The Contractor shall provide full details of the coating process to AEGCL for approval.

It is the responsibility of the Contractor to ensure that the quality of paints used shall withstand the tropical heat and extremes of weather conditions specified in the schedules. The paint shall not peel off, wrinkle, be removed by wind, storm and handling on site and the surface finish shall neither rust nor fade during the service life of the equipment.

The colours of paints for external and internal surfaces shall be in accordance with the approved colour schemes.

7.11.2. Works painting processes

All steelworks, plant supporting steelworks and metalwork, except galvanised surfaces or where otherwise specified, shall be shot blasted to BS 7079 or the equivalent ISO standard. All sheet steel work shall be degreased, pickled, phosphated in accordance with the IS 6005 “Code of Practice for phosphating iron and sheet steel”. All surfaces shall then be painted with one coat of epoxy zinc rich primer, two pack type, to a film thickness of 50 microns. This primer shall be applied preferably by airless spray and within twenty minutes but not exceeding one hour of shot blasting.

All rough surfaces of coatings shall be filled with an approved two pack filler and rubbed down to a smooth surface.

The interior surfaces of all steel tanks and oil filled chambers shall be shot blasted in accordance with BS 7079 or the equivalent ISO, and painted within a period of preferably twenty minutes, but not exceeding one hour with an oil resisting coating of a type and make to the approval of AEGCL.

The interior surfaces of mechanism chambers, boxes and kiosks, after preparation, cleaning and priming as required above, shall be painted with one coat zinc chromate primer, one coat phenolic based undercoating, followed by one coat phenolic based finishing paint to a light or white colour. For equipment for outdoor use this shall be followed by a final coat of anti-condensation paint of a type and make to the approval of AEGCL, to a light or white colour. A minimum overall paint film thickness of 150 microns shall be maintained throughout.

All steelworks and metalwork, except where otherwise specified, after preparation and priming as required above shall be painted with one coat metallic zinc primer and two coats of micaceous iron oxide paint followed by two coats of either phenolic based or enamel hard gloss finished coloured paint to the approval to an overall minimum paint film thickness of 150 microns.

Galvanised surfaces shall not be painted in the works.

All nuts, bolts, washers etc., which may be fitted after fabrication of the plant shall be painted as described above after fabrication.

The painted metal works shall be subjected to paint qualification test as per draft ANSI/IEEE-Std. 37.21-1985 clause 5.2.5.

7.11.3. Site painting

After erection at site, the interior surfaces of mechanism chambers and kiosks shall be thoroughly examined, and any deteriorated or mechanically damaged surfaces of such shall be made good to the full Specification described above.

After installation/erection at site all surfaces of steelworks and metalwork shall be thoroughly washed down. Any deteriorated or otherwise faulty paint-work removed down to bare metal and made good to the full Specification described above, then painted one further coat of phenolic based undercoating and one coat phenolic based hard gloss finishing paint to provide an overall minimum paint film thickness of 200 microns.

Any nuts, bolts, washers, etc., which have been removed during site erection, or which may be required to be removed for maintenance purposes shall be restored to their original condition.

All paint work shall be left clean and perfect on completion of the works.

7.12 Colour Schemes

The Contractor shall propose a colour scheme for the sub-station for the approval of AEGCL. The decision of AEGCL shall be final. The scheme shall include:

- Finishing colour of indoor equipment
- Finishing colour of outdoor equipment
- Finish colour of all cubicles
- Finishing colour of various auxiliary system equipment including piping.
- Finishing colour of various building items.

All steel structures, plates etc. shall be painted with non-corrosive paint on a suitable primer. It may be noted that normally all Employer's electrical equipment in Employer's switchyard are painted with shade 631 of IS: 5 and Employer will prefer to follow the same for this project also. All indoor cubicles shall be of same colour scheme and for other miscellaneous items colour scheme will be subject to the approval of AEGCL.

Sl. No.	Equipment	Application Environment			
		Indoor		Outdoor	
		Colour	Code IS:5	Colour	Code IS:5
400kV/220kV/132kV Class Equipment					
1	Transformers	—	—	Light grey	631
2	Marshalling boxes, CTs, PT's, CVT's, surge counter casings, junction boxes etc.	Light Admiralty grey.	697	Light Admiralty grey.	697
3	Control and relay panels, PLCC	Smoke grey	692	—	—
4	Porcelain parts i.e. insulators	Dark brown	412	Dark brown	412
5	All structures/ metallic parts exposed to atmosphere	Hot dip galvanised			
33kV Class equipment					
6	Switchgear cubicles	Smoke grey	692	Light grey	631
7	Control and relay panels	Smoke grey	692	—	—
	LT switchgear				
8	LT switchgear exterior	Smoke grey	692	Light grey	631
9	ACDB/ MCC	Smoke grey	692	Light grey	631
10	DCDB	Smoke grey	692	—	—
11	LT bus duct in side enclosure	Matt Paint		—	—
12	LT bus duct outside enclosure	Smoke grey	692	—	—
13	Motors	Smoke grey	692	Light grey	631
14	Diesel generator engine	Smoke grey	692	—	—
15	Diesel generator	Smoke grey	692	—	—
16	LT transformers	Smoke grey	692	Light grey	631
17	Battery charger	Smoke grey	692	—	—
18	Mimic diagram				
	400kV	Dark violet	796	—	—
	220kV	Golden yellow	356	—	—
	132kV	Sky blue	101	—	—
	33kV	Signal red	537	—	—
	11kV	Canary yellow	309	—	—
	415V	Middle brown	411	—	—
	Miscellaneous				
19	Control modules and console	Smoke grey	692	Light grey	631

20	Lighting package equipment	Light grey	631	Light grey	631
21	Lighting package equipment inside	Glossy white		Glossy	
22	Water pipes	sea green	217	sea green	217
23	Air pipes	Sky blue	101	Sky blue	101
24	Transformer oil pipes	Light brown	410	Light	410
25	Fire Installations	Fire red	536	Fire red	536
26	Insulating oil/ gas treatment plant	Gulf red	473	Gulf red	473

Table: Recommended colour schemes

The above specification are general guidelines. If specific requirement is made for individual items, that will supersede the above details.

7.13. Provision for exposure to hot and humid climate

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

7.13.1. Anti-condensation Provisions:

Space heaters where provided shall be suitable for continuous operation at 240V supply voltage. On- off switch and fuse shall be provided.

One or more adequately rated permanently or thermostatically connected heaters shall be supplied to prevent condensation in any compartment. The heaters shall be installed in the lower portion of the compartment and electrical connections shall be made from below the heaters to minimise deterioration of supply wire insulation. The heaters shall be suitable to maintain the compartment temperature at approximately 10C, above the outside air temperature to prevent condensation. This shall be demonstrated by tests.

7.13.4. Labels and plates

All apparatus shall be clearly labelled indicating, where necessary, its purpose and service positions. Each phase of alternating current and each pole of direct current equipment and connections shall be coloured in an approved manner to distinguish phase or polarity.

The material of all labels and the dimensions, legend, and method of printing shall be to approval. The surface of indoor labels shall have a matt or satin finish to avoid dazzle from reflected light.

Colours shall be permanent and free from fading. Labels mounted on black surfaces shall have white lettering. „Danger" plates shall have red lettering on a white background.

All labels and plates for outdoor use shall be of non-corroding material. Where the use of enamelled iron plates is approved, the whole surface including the back and edges, shall be properly covered and resistant to corrosion. Protective washers of suitable material shall be provided front and back on the securing screws.

Labels shall be engraved in English. Name plates shall be white with black engraved lettering and shall carry all the applicable information specified in the applicable items of the Standards. Any other relevant information which may be required for groups of smaller items for which this is not possible e.g. switch bays etc. a common name plate in English and Assamese with the title and special instructions on it shall be provided.

No scratching, corrections or changes will be allowed on name plates.

All equipment mounted on front and rear sides as well as equipment mounted inside the panels shall be provided with individual name plates with equipment designation engraved.

On the top of each panel on front as well as rear sides large name plates with bold size lettering shall be provided for circuit/ feeder/ cubicle box designation.

All front mounted equipment shall be also provided, at the rear, with individual name plates engraved

with tag numbers corresponding to the one shown in the panel internal wiring to facilitate tracing of the wiring. The name plates shall be mounted directly by the side of the respective equipment wiring.

Name plates of cubicles and panels may be made of non-rusting metal or 3 ply lamicoid. These name plates may be black with white engraved lettering.

The name plate inscription and size of name plates and letters shall be submitted to AEGCL for approval.

The nameplates of the apparatus shall include, at least, the information listed below, together with any other relevant information specified in the applicable standards:

- Concise descriptive title of the equipment
- Rating and circuit diagrams
- Manufacturer's name, trademark, model type, serial number
- Instruction book number
- Year of manufacture
- Total weight (for capacitor racks indicate weight, for capacitors indicate quantity of liquid)
- Name of the project.

Each measuring instrument and meter shall be prominently marked with the quantity measured e.g. kV, A, MW etc. All relays and other devices shall be prominently marked with manufacturers name, manufacturer’s type, serial number and electrical rating data.

Danger plates and plates for phase colours shall be provided as per requirement. The Contractor shall devise a system to designate equipment and sub-systems. The nameplates/labels displaying these designations shall be installed at appropriate locations. Whenever motion or flow of fluids is involved, plates showing direction of motion or flow shall also be provided.

7.13.5. Pad Locks

For each item of plant, the Contractor shall provide a padlockable handle and a non-ferrous padlock with different key changes in order to prevent access to control cabinets, cubicles and relay panels. The Contractor shall provide two keys for each lock and a master key for each substation.

Cabinets for the accommodation of padlocks and keys, whilst not in use, shall be provided and shall be suitably labelled so that keys will be readily identifiable.

7.13.7. Lubrication

Bearings which require lubrication either with oil or grease shall be fitted with nipples.

7.14 PRODUCTION PROCESS REQUIREMENTS

7.14.1 Castings

7.14.1.1. General

All castings shall be true to pattern, free from defects and of uniform quality and condition. The surfaces of castings which do not undergo machining, shall be free from foundry irregularities. The castings shall be subject to NDT, chemical, mechanical and metallographic tests. Details of the same shall be furnished to AEGCL for review/approval. Magnetic particle inspection (MPI) test, wherever applicable, shall be carried out in longitudinal and transverse direction to detect radial and axial cracks.

7.14.1.2. Iron castings

Iron casting material shall be in accordance with ASTM A 126 Class B. A copy of the ladle analysis shall be sent to AEGCL. Each casting shall have a test bar from which tension test specimens may be taken. Test specimen shall be in accordance with ASTM A 370 and tested in accordance with ASTM E8. The Contractor shall submit his procedures for testing and acceptance for iron castings for approval by AEGCL.

7.14.1.3. Steel castings

Steel castings shall be manufactured in accordance with ASTM A 27 and shall be subjected to appropriate tests and inspection as detailed herein.

Copies of mandatory documentation, such as ladle analyses and mechanical test results, shall be sent to AEGCL. (Non-ferrous casting material and castings shall be manufactured in accordance with the appropriate ASTM standards for the material concerned).

7.14.2. Forgings

When requested by AEGCL, forgings will be subjected to inspection in the regions of fillets and changes of section by suitable method. Magnetic particle, dye-penetration, radiographic or ultrasonic, or any combination of these methods may be used to suit material type and forging design.

The testing is to be carried out after the rough machining operation and is to be conducted according to the appropriate ASTM standards.

MPI test on forging shall be carried out to detect both radial and axial cracks. Ferrous forgings shall be demagnetised after such tests.

Any indentations which prove to penetrate deeper than 2.5% of the finished thickness of the forging shall be reported to AEGCL giving location, length, width and depth. Any indentations which will not machine out during final machining shall be gouged out and repaired using an approved repair procedure.

Repair of rotating elements by welding will only be accepted subject to detailed examination of the proposal by AEGCL prior to the repair being carried out.

The forging shall be tested for mechanical and metallographic tests as per ASTM. The details shall be mutually discussed/agreed upon.

7.14.3. Fabricated components

All components machined or fabricated from plate, sheet or bar stock shall meet the material requirements of ASTM or material specification approved by AEGCL.

Structural steel, rolled shapes, bars, etc. shall comply with the latest ASTM for A36.

Plate steel shall be of a designation and quality suitable for the function it is intended to perform. Insofar as it is compatible with its function, it shall comply with ASTM A283 structural quality.

All, or a representative number of such components, shall be subjected to one or more of the following tests: visual, dye penetration, magnetic particle (transverse and longitudinal), ultrasonic or radiographic. These tests shall be in accordance with the recommended practices of the ASTM. The terms of reference for acceptance shall be the applicable ASTM Specifications.

7.14.4. Welding and welder’s qualifications

7.14.4.1. General

All welding shall be carried out by qualified welders only. All welding shall be in accordance with the corresponding standards of the American Welding Society or the American Society of Mechanical Engineers. Other standards to determine the quality of welding process and qualifications of welders may be considered, provided that sufficient information is first submitted for the approval of AEGCL. Prior to the start of fabrication, the Contractor shall submit to AEGCL for approval, a description of each of the welding procedures which he proposes to adopt, together with certified copies of reports of the results from tests made in accordance with these procedures. The Contractor shall be responsible for the quality of the work performed by his welding organisation. All welding operators, to be assigned work, including repair of casting, shall pass the required tests for qualification of welding procedures and operators. AEGCL reserves the right to witness the qualification tests for welding procedures and operators and the mechanical tests at the samples. The Contractor shall bear all his own expenses in connection with the qualification tests. If the work of any operator at any time appears questionable, such operator will be required to pass appropriate pre- qualification tests as specified by the Inspector and at the expense of the Contractor.

7.14.4.2. Welding

All welding shall be performed in accordance with the appropriate standards. The design and construction of welded joints subject to hydraulic pressure shall conform to the applicable requirement of ASME “Boiler and Pressure Vessel Code” shall be qualified in accordance with Section IX of this Code. The design and construction of welded joints not subjected to hydraulic pressure shall, as a minimum, conform to the requirements of AWS “Specification for Welded Highway and Railway

Bridge” D2.0. Except for minor parts and items specifically exempted from stress relieving, all shop- welded joints shall be stress relieved in accordance with the requirements of the ASME “Boiler and Pressure Vessel Code” Section VIII.

In addition to satisfying the procedural and quality requirements set forth in the applicable code and/or these Specifications, all welding shall meet the following requirements for workmanship and visual quality:

- Butt welds shall be slightly convex, of uniform height and shall have full penetration.
- Fillet welds shall be of the specified size, with full throat and legs of equal length.
- Repairing, chipping and grinding of welds shall be done in a manner which will not gouge, groove or reduce the thickness of the base metal.
- The edges of the member to be joined shall expose sound metal, free from laminations, surface defects caused by shearing or flame-cutting operations or other injurious defects.

Welded joints subject to critical working stress shall be tested by approved methods of non-destructive testing, such as radiographic and ultrasonic examination, magnetic particle and liquid penetration inspection. All expenses in connection with these tests shall be borne by the Contractor. The extent of testing shall be as stipulated by the ASME “Boiler and Pressure Vessel Code”, Section VIII, but without prejudice to the rights of the Inspector or AEGCL to ask for additional tests,

The arc-welding process to be used and the welding qualifications of the welders employed on the work shall be used in accordance with AWS requirements and Section VIII and IX of the ASME (American Society of Mechanical Engineers) Code, latest edition, as they may apply. All welding rods shall conform to the requirements of the latest issue of Section It, part C of the ASME Code.

Gas shielded welding (TIG or MIG) used as appropriate for aluminium, stainless steel or other material shall be carried out in accordance with the best commercial practice and the following standard specifications:

- Specifications for copper and copper-alloy welding rods (AWS A5.7, ASTM B259)
- Specification for corrosion-resisting chromium and chromium-nickel steel welding rods and bare electrodes (AWS A5.9, ASTM A371)
- Specifications for aluminium and aluminium alloy rods and bare electrodes (AWS A5.10, ASTM B285).
- Specifications for nickel and nickel-base alloy bare welding filler metal (AWS A5.14, ASTM B304).

Gas welding will not normally be used in the equipment. When a particular equipment manufacture requires the use of gas welding, the proposed process and the welder's qualification shall be in accordance with AWS B3.0. Welding of galvanised components will not be allowed in the equipment. Strict measures of quality control shall be exercised throughout the Equipment/ Works. AEGCL may call for an adequate NDT test of the work of any operator, who in his opinion is not maintaining the standard of workmanship. Should this NDT test prove defective, all work done by that operator, since his last test shall be tested at the Contractor's expense. If three or more of these tests prove defective, the operator shall be removed from the project. A procedure for the repair of defects shall be submitted to AEGCL for his approval prior to any repairs being made.

7.14.4.3. Welding of pipes

Before welding, the ends shall be cleaned by wire brushing, filing or machine grinding. Each weld-run shall be cleaned of slag before the next run is deposited. Welding at any joint shall be completed uninterrupted. If this cannot be followed for some reason, the weld shall be insulated for slow and uniform cooling. Welding shall be done by manual oxy-acetylene or manual shielded metal are process. Automatic or semi-automatic welding processes may be done only with the specific approval of AEGCL. As far as possible welding shall be carried out in flat position. If not possible, welding shall be done in a position as close to flat position as possible. Downward technique is not allowed while welding pipes in horizontal position, unless permitted by AEGCL. Combination of welding processes or usage of electrodes of different classes or makes in a particular joint shall be allowed only after the welding procedure has been duly qualified and approved by AEGCL. No backing ring shall be used for circumferential butt welds. Welding carried out in ambient temperature of 5C or below shall be heat treated.

A spacer wire of proper diameter may be used for weld root opening but must be removed after tack welding and before applying root run.

Tack welding for the alignment of pipe joints shall be done only by qualified welders. Since tack welds form part of final welding, they shall be executed carefully and shall be free from defects. Defective welds shall be removed prior to the welding of joints.

Electrodes size for tack welding shall be selected depending upon the root opening. Tack welds should be equally spaced.

Root run shall be made with respective electrodes/filler wires. The size of the electrodes shall not be greater than 3.25 mm (10 SWG) and should preferably be 2.3 mm (12 SWG). Welding shall be done with direct current values recommended by the electrode manufacturers.

Upward technique shall be adopted for welding pipes in horizontally fixed position. For pipes with wall thickness less than 3 mm, oxyacetylene welding is recommended.

The root run of butt joints shall be such as to achieve full penetration with the complete fusion of root edges. The weld projection shall not exceed 3 mm inside the pipe.

On completion of each run craters, weld irregularities, slag etc. shall be removed by grinding or chipping.

During the process of welding, all movements, shocks, vibration or stresses shall be carefully avoided in order to prevent weld cracks.

Fillet welds shall be made by shielded metal arc process regardless of thickness and class of piping. Electrode size shall not exceed 10 SWG. (3.25 mm). At least two runs shall be made on socket weld joints.

7.15 WIRING, CABLING AND CABLE INSTALLATION

7.15.1 Cubicle wiring

Panels shall be complete with interconnecting wiring between all electrical devices in the panels. External connections shall be achieved through terminal blocks. Where panels are required to be located adjacent to each other all inter panel wiring and connections between the panels shall be carried out internally. The Contractor shall furnish a detailed drawing of such inter panel wiring. The Contractor shall ensure the completeness and correctness of the internal wiring and the proper functioning of the connected equipment.

All wiring shall be carried out with 1.1 kV grade, PVC/XLPE insulated, single core, stranded copper wires. The PVC shall have oxygen index not less than ‘29’ and Temperature index not less than 250°C (for XLPE cable). The wires shall have annealed copper conductors of adequate size comprise not less than three strands

The minimum cross-sectional area of the stranded copper conductor used for internal wiring shall be as follows:

- All circuits excepting CT circuits and energy metering circuit of VT 2.5 sq.mm
- All CT circuits and metering circuit of VT 2.5sq. mm

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

Cubicle connections shall be insulated with PVC to IEC 227. Wires shall not be jointed or teed between terminal points.

Bus wires shall be fully insulated and run separately from one another. 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 panel suite. Longitudinal troughs extending throughout the full length of panel shall be preferred for inter panel wiring.

All inter-connecting wires between adjacent panels shall be brought to a separate set of terminal blocks located near the slots of holes meant for the passage of the inter-connecting wires. Interconnection of adjacent panels on site shall be straightforward and simple. The bus wires for this purpose shall be bunched properly inside each panel.

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. Numbers 6 and 9 shall not be included for ferrules purposes unless the ferrules have numbers underscored to enable differentiation. (i.e. 6 and 9).

Fuses and links shall be provided to enable all circuits in a cubicle, except a lighting circuit, to be isolated from the bus wires.

The DC trip and AC voltage supplies and wiring to main protective gear shall be segregated from those for back-up protection and also from protective apparatus for special purposes. Each such group shall be fed through separate fuses from the bus wires. There shall not be more than one set of supplies to the apparatus comprising each group. All wires associated with the tripping circuits shall be provided with red ferrules marked “Trip”.

It shall be possible to work on small wiring for maintenance or test purposes without making a switchboard dead.

The insulation material shall be suitably coloured in order to distinguish between the relevant phases of the circuit.

When connections rated at 380 volt and above are taken through junction boxes they shall be adequately screened and “DANGER” notices shall be affixed to the outsides of junction boxes or marshalling kiosk.

Where connections to other equipment and supervisory equipment are required the connections shall be grouped together.

The above specification are general guidelines. If specific requirement is made for individual items, that will supersede the above details.

7.15.2 LV power cabling

LVAC cable terminals shall be provided with adequately sized, hot pressed, cast or crimp type lugs. Where sweating sockets are provided, they shall be without additional clamping or pinch bolts. Where crimp type lugs are provided, they shall be applied with the correct tool and the crimping tool shall be checked regularly for correct calibration. Bi-metallic joints between the terminals and lugs shall be provided where necessary.

Terminals shall be marked with the phase colour in a clear and permanent manner.

A removable gland plate shall be provided by the Contractor. The Contractor shall be responsible for drilling the cable gland plate.

Armoured cables shall be provided with suitable glands for terminating the cable armour and shall be provided with an earthing ring and lug to facilitate connection of the gland to the earth bar.

The above specification are general guidelines. If specific requirement is made for individual items, that will supersede the above details.

7.15.3 Multi-core cables and conduit wiring

External multi-core cabling between items of main and ancillary equipment shall form part of the Contract Works and shall consist of armoured multi-core cable with stranded copper conductors PVC/XLPE insulated and PVC over sheathed complying with the requirements of IEC 227 and 228 as applicable.

Multi-core cable for instrumentation and control purposes shall be supplied with 2.5 mm2 stranded copper cores. Multi-core cables for CT and VT circuits shall be supplied with two by 2.5 mm2 stranded copper cores and the cores shall be identified by the phase colour.

Where conduit is used the runs shall be laid with suitable falls and the lowest parts of the run shall be external to the equipment. All conduit runs shall be adequately drained and ventilated. Conduits shall not be run at or below ground level.

Multi-core cable tails shall be so bound that each wire may be traced to its cable without difficulty. All multi-core cables shall be provided with 20 % spare cores and the spare cores shall be numbered and terminated at a terminal block in the cubicle. Where cables are terminated in a junction box and the connections to a relay or control cubicle are continued in conduit, the spare cores shall be taken through the conduit and terminated in the cubicle. The dc trip and ac voltage circuits shall be segregated from each other as shall the circuits to main protective gear be segregated from those for back-up protection.

The screens of screened pairs of multi-core cables shall be earthed at one end of the cable only. The position of the earthing connections shall be shown clearly on the diagram.

All wires on panels and all multi-core cable cores shall be crimped with the correct size of crimp and crimping tool and will have ferrules which bear the same number at both ends. At those points of interconnection between the wiring carried out by separate contractors where a change of number cannot be avoided double ferrules shall be provided on each wire. The change of numbering shall be shown on the appropriate diagram of the equipment. The same ferrule number shall not be used on wires in different circuits on the same panels.

The Contractor shall provide a two (2) metre loop of spare cable at both ends of all multi-core cable runs and shall leave sufficient lengths of tails at each end of the multi-core cables to connect up to the terminal boards. The Contractor shall also strip, insulate, ring through and tag the tails and shall also seal the cable boxes. The Contractor shall be responsible for re-checking the individual cores and for the final connecting up and fitting of numbered ferrules within all equipment provided on this contract.

The drilling of gland plates, supply and fitting of compression glands and connecting up of power cables included in the Contract scope of work shall be carried out under this contract.

7.15.4 Laying and installing of cables

7.15.4.1. General

For cable laying the following shall apply:

- Switchyard area in concrete cable troughs (cable trench having cable racks with cable Trays)
- Control Room On cable racks consisting of slotted type and ladder type cable trays
- Buildings Conduits

Directly buried cables shall be used wherever necessary with the approval of AEGCL.

7.15.4.2. Laying of cable

Cables shall be laid in concrete troughs provided under this contract or drawn into pipes or ducts or on cable racks or directly buried as may be required by AEGCL. Concrete troughs shall be designed so that the cables are supported on cable support systems and the supports shall be arranged so as to allow the segregation of power, control (including CT and VT circuits) and communications cables onto different layers of cable supports. All cable supports shall be earthed in accordance with IS 3043. The minimum vertical separation between layers of cable tray shall be not less than 300 mm.

The cable support system shall be designed and constructed to carry the required cables without undue crowding of the supports and without overloading the supports. The maximum number of layers of cable that shall be permitted on a single cable support shall be three. The width of the cable supports shall be selected to ensure that the supports are not crowded, the cable supports are not overloaded, and that sufficient space is provided in the cable trough to allow for personnel access during and after cable installation. The width of cable supports should not exceed 750 mm.

Cables shall be laid direct in the ground only at the discretion of AEGCL. All cables laid direct in the ground outside buildings shall be laid in a trench and protected by reinforced concrete slabs or cable tiles.

For auxiliary cables the top of the slab or tile shall be at a depth not less than 300 mm below the surface of the ground and there shall be a layer of fine well packed riddled earth 75 mm thick in between the cable and the bottom of the trench and between the top of the cable and the underside of the slab.

The Contractor shall be responsible for the proper laying of all cables in the ground. Where cables in the same trench are laid over each other, they shall be separated by not less than 75 mm of riddled earth. The riddled earth used for this purpose shall have been passed through a screen having a 12 mm square mesh.

Where cables pass under roadways, they shall be laid in pipes at a depth not less than 800 mm below the surface.

The Contractor shall be responsible for the excavation of trenches which shall include all pumping and baling required and the provision of all necessary labour, plant, tools, water, additional soil, fuel or motor power for such purposes.

Cables in trenches will be inspected by AEGCL before the trenches are backfilled. Backfilling of cable trenches should be carried out as per relevant IS standards.

The running of communications and power cables along the same route shall be avoided as far as possible. Where this is not possible, they shall be segregated, the one group from the other. Power and communication cables shall be laid in separate tiers. For other than directly buried cables the order of laying of various cables shall be as follows:

- Power cables on top tiers.
- Control/ instrumentation/Communication and other service cables in bottom tiers.

7.15.4.3. 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 conforming to IS 280. Cable tags shall be of rectangular shape for power cables and of circular shape for control cables.

Location of cables laid directly in the ground shall be clearly indicated with cable marker made of galvanised iron plate.

Location of buried cable joints shall be indicated with a cable marker having an additional inscription "Cable joint".

Cable markers 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 every twenty meters (20 m) in cable tray/trench runs. Cable tags shall be provided inside switchgear, motor control centres, control and relay panels etc. and wherever required for cable identification when a number of cables enter together through a gland plate.

The price of cable tags and markers shall be included in the installation rates for cables/conduits quoted by the Bidder.

7.15.4.4. Cable supports and cable tray mounting arrangements in control room

The control room will normally be provided with embedded steel inserts on concrete floors/walls for the purpose of cabling in the control room. The supports shall be secured by welding to these inserts or available building steel structures. However, in cases where no such embedded steel inserts are available, the same shall have to secured to the supports on walls or floors by suitable anchoring.

7.15.4.5. Cable support structure in switchyard cable trenches

The contractor shall fabricate and install cable support structures in cable trenches. These supports shall be provided at 750 mm spacing along the run of cable trenches.

Cable supports and cable racks shall be fabricated from standard structural steel members, channels, angles and flats of required size. The fabrication welding and erection of these structures shall conform to the relevant clauses of this Specification, in addition to the specification given herein.

7.15.5. Termination of cables and wires

Where cables leave the apparatus in an upward direction the cable boxes shall be provided with a barrier joint to prevent leakage of cable oil or compound into the apparatus. Where cable cores are liable to contact with oil or oil vapour the insulation shall be unaffected by oil.

PVC sheathed cables shall be terminated by compression glands complying with BS 6121 (or equivalent).

Auxiliary PVC insulated cables shall be terminated with compression type glands, clamps or armour clamps complete with all the necessary fittings.

Colours shall be marked on the cable box, cable tail ends and single core cables at all connecting points and/or any positions AEGCL may determine. Cable boxes shall be provided with suitable labels indicating the purpose of the supply where such supply is not obvious or where AEGCL may determine.

All cables shall be identified and shall have phase colours marked at their termination.

All incoming and outgoing connections shall be terminated at a terminal block. Direct termination into auxiliary switches will not be accepted.

The above specification are general guidelines. If specific requirement is made for individual items, that will supersede the above details.

7.16 DEGREES OF PROTECTION

Degrees of protection shall be provided in accordance with IEC 144 and IEC 529 and be as follows:

- For outdoor applications, IP 55/ IP 65.
- For indoor applications where purpose-built accommodation is provided, e.g. switch and control and relay rooms in auxiliary plant buildings, IP 43.
- Where dust can adversely affect equipment within the enclosure, this equipment should be separately housed with a degree of protection of IP 52.
- For indoor applications where the equipment is housed in the same building as that enclosing water and steam operated equipment, the degrees of protection stated in the previous paragraph shall be up rated to IP 44 and IP 54 respectively.

Where more severe environments exist, e.g. steam and oil vapour or other deleterious chemical environments, special measures will be necessary, and the degree of protection required will be specified separately.

The Contractor shall submit a schedule for providing the degree protection to various control boxes, junction boxes etc. for AEGCLs approval.

The above specification are general guidelines. If specific requirement is made for individual items, that will supersede the above details.

7.17 SUPPLY VOLTAGE

All incoming supplies of greater than 125V to earth shall have their termination shrouded by a suitable insulating material.

The auxiliary supply voltages on site shall be as follows:

Nominal Voltage V	Variation	Frequency Hz or DC	Phase	Wires	Neutral Connection
430	±10%	50±5%	3	4	Solidly earthed
240	±10%	50±5%	1	2	Solidly earthed
220	187V - 242V	DC	DC	2	Isolated 2 wires
110	100V - 121V	DC	DC	2	Isolated 2 wires
50	45V - 55V	DC	DC	2	+ve earthed

7.18 MAINTENANCE TELEPHONE POSITIONS

Telephone jack plug points shall be provided at each circuit breaker, at each power transformer marshalling kiosk and, on each control, and relay panel. At each substation these plug points are to be connected in parallel to form a site telephone circuit for use during maintenance and testing operations.

7.19 ERECTION CONDITIONS

7.19.1 General

The following shall supplement the conditions already contained in the other parts of these specifications and documents and shall govern that portion of the work on this Contract to be performed at Site.

7.19.2 Regulation of local authorities and statutes

The Contractor shall comply with all the rules and regulations of local authorities during the performance of his field activities. He shall also comply with the Minimum Wages Act, 1948 and thepayment of Wages Act (both of the Government of India and Govt of Assam) and the rules made there under in respect of any employee or workman employed or engaged by him or his Sub-Contractor.

The Contractor shall ensure that he obtains, from the Government of Assam, an Electrical Contractor’s Licence and a supervisory certificate of the appropriate grade to allow him to execute the electrical works included in the Contract. The Contractor shall ensure that all workmen possess Workman Permits, issued by the Government of Assam, for engagement in the Contract Works.

7.19.3 Inspection, testing and inspection certificates

The provisions of the General Conditions of Contract shall also be applicable to the erection portion of the Works. AEGCL shall have the right to re-inspect any equipment though previously inspected and approved by him at the Contractor's works, before and after the same are erected at Site.

7.19.4 Contractor's field operation

7.19.4.1. General

The Contractor shall inform AEGCL in advance of field activity plans and schedules for carrying-out each part of the works. Any review of such plans or schedules or methods of work by AEGCL shall not relieve the Contractor of any of his responsibilities towards the field activities. Such reviews shall not be considered as an assumption of any risk or liability by the Employer or any of his representatives, and no claim of the Contractor will be entertained because of the failure or inefficiency of any such plan or schedule or method of work reviewed. The Contractor shall be solely responsible for the safety, adequacy and efficiency of plant and equipment and his erection methods.

7.19.5. Facilities to be provided by the contractor

7.19.5.1. Unloading

Contractor shall make his own arrangement for unloading the equipment at site.

7.19.5.2. Tools, tackle and scaffoldings

The Contractor shall provide all the construction equipment tools, tackle and scaffoldings required for offloading, storage, pre-assembly, erection, testing and commissioning of the equipment covered under the Contract. He shall submit a list of all such materials to AEGCL before the commencement of pre-assembly at Site. These tools and tackles shall not be removed from the Site without the written permission of AEGCL.

7.19.6. First-Aid and general hygiene

The Contractor shall provide necessary first-aid facilities for all his employees, representatives and workmen working at the site. At all times at least ten percent of all Contractors personnel assigned to the worksite shall be trained in administering first-aid.

The labour colony, offices and residential areas of the Contractor’s employees and workmen shall be kept clean and neat to the entire satisfaction of AEGCL. Proper sanitary arrangements shall be provided by the Contractor in work-areas, offices and residential areas of the Contractor.

Waste oil shall be disposed of in a manner acceptable to AEGCL. Under no circumstances shall waste oil be dumped into uncontrolled drains.

7.19.7. Security

The Contractor shall have total responsibility for all equipment and material in his custody, stored, loose, semi-assembled and/or erected by him at Site. The Contractor shall make suitable security arrangements including employment of security personnel to ensure the protection of all materials, equipment and works from theft, fire, pilferage and any other damages and loss.

7.19.8. Materials handling and storage

All the materials stored in the open or dusty location shall be All the equipment furnished under the Contract and arriving at Site shall be promptly received, unloaded and transported and stored in the stores by the Contractor.

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

The Contractor shall maintain an accurate and exhaustive record detailing all equipment received by him for the purpose of erection and keep such record open for the inspection of AEGCL.

All equipment shall be handled carefully to prevent any damage or loss. All equipment stored shall be properly protected to prevent damage. Equipment from the store shall be moved to the actual location at an appropriate time so as to avoid damage of such equipment at Site.

covered with suitable weather-proof and flameproof covering material.

The Contractor shall be responsible for making suitable indoor facilities for the storage of all equipment which requires to be kept indoors.

7.19.9 Construction Management

7.19.9.1 General

Time is the essence of the Contract and the Contractor shall be responsible for performance of his Works in accordance with the specified construction schedule. If at any time the Contractor is falling behind the schedule, he shall take necessary action to make good for such delays by increasing his work force or by working overtime to accelerate the progress of the work and to comply with schedule and shall communicate such actions in writing to AEGCL, providing evidence that his action will compensate for the delay. The Contractor shall not be allowed any extra compensation for such action.

7.19.10 Field office records

The Contractor shall maintain at his Site office up-to-date copies of all drawings, specifications and other supplementary data complete with all the latest revisions thereto. The Contractor shall also maintain in addition the continuous record of all changes to the above contract documents, drawings, specifications, supplementary data, etc. effected at the field. On completion of his total assignment under the Contract, such drawings and engineering data shall be submitted to AEGCL in the required number of copies.

7.19.11 Protection of property and Contractor's liability

The Contractor will ensure provision of necessary safety equipment such as barriers, sign-boards, warning light and alarms, personal protective equipment etc. to provide adequate protection to persons and property. The Contractor shall be responsible for giving reasonable notice to AEGCL and the owners of public or private property and utilities when such property and utilities are likely to be damaged or injured during the performance of his works, and shall make all necessary arrangements with such owners, related to removal and/or replacement or protection of such property and utilities.

7.20 EMPLOYER'S SUPERVISION

To eliminate delays and avoid disputes and litigation, it is agreed between the Parties to the Contracts that all matters and questions shall be referred to the Employer and without prejudice the Contractor shall proceed to comply with the Employer's decision.

The work shall be performed under the direction and supervision of AEGCL & PMC. The scope of the duties of AEGCL, pursuant to the contract, will include but not be limited to the following:

- Interpretation of all the terms and conditions of these documents and specifications.
- Review and interpretation of all the Contractors drawing, engineering data etc.

- Witness or authorise his representative to witness tests and trials either at the manufacturer's works or at site, or at any place where work is performed under the Contract.
- Inspect, accept or reject any equipment, material and work under Contract.
- Issue certificate of acceptance and/or progressive payment and final payment certificates.
- Review and suggest modification and improvements in completion schedules from time to time.
- Supervise the Quality Assurance program implementation at all stages of the Works.

7.21 TESTING AND INSPECTION

7.21.1 General Conditions of Type Test.

The Contractor shall carry out the tests stated in accordance with the conditions of this Specification, without extra charge for such additional tests as in the opinion of AEGCL are necessary to determine that the Contract Works comply with this Specification. The tests shall be carried out generally in accordance with the relevant IEC's or IS. However, in the absence of relevant regulations in IEC / IS, other appropriate international standards may be accepted at AEGCL's discretion. The specific details of testing and inspection are given in the appropriate section of this Specification.

The Contractor shall submit Type Test Reports for all equipment excluding GIS being supplied by him (as per IEC standard) which, shall not be older than five (5) years, as on date of bid opening for AEGCL's approval. AEGCL may also give instruction to carry out Type Tests, routine tests or acceptance tests. No charges shall be paid by AEGCL for any Type Test.

7.21.2. Mandatory Type Test for GIS Equipments

The manufacturer shall furnish the certificates confirming successful conduction of the following Type Tests for GIS. The tests carried out shall not be older than Ten (10) years from the date of issue of LOA.

1. Tests to verify the insulation level (Lightning impulse, switching impulse and ac withstand test with PD) test on each GIS device (CB, Disconnector, bus etc.)
2. Dielectric tests on auxiliary circuits.
3. Tests to prove the radio interference voltage (RIV) level.
4. Tests to prove the temperature rise of any part of the equipment and measurement of the resistance of the main circuit.
5. Tests to prove the ability of the main and earthing circuits to carry the rated peak and the rated short time withstand current.
6. Tests to verify the making and breaking capacity of the included switching devices.
7. Tests to prove the satisfactory operation of the included switching devices.
8. Tests to prove the strength of enclosures.
9. Verification of the degree of protection of the enclosure.
10. Gas tightness tests
11. Electromagnetic compatibility tests (EMC).
12. Additional tests on auxiliary and control circuits.
13. Tests on partitions.
14. Tests to prove the satisfactory operation at limit temperatures.

15. Tests to prove performance under thermal cycling and gas tightness tests on insulators.
16. Corrosion test on earthing connections (if applicable).
17. Tests to assess the effects of arcing due to an internal fault.
18. Tests on solid dielectric components (operating rods, spacers, etc)
19. Seismic test
20. Test on Auxiliary switches (Electrical & Mechanical Endurance, Heat run, IR & HV test)

All materials used shall be subjected to such routine tests as are customary in the manufacture of the types of plant included in the Contract Works. These materials shall withstand satisfactorily in all such tests.

All tests shall be carried out to the satisfaction of AEGCL, in presence of authorised representative of AEGCL, at such reasonable times as AEGCL may require, unless agreed otherwise. Not less than three weeks' notice of all tests shall be given to AEGCL in order that AEGCL may be represented if AEGCL so desires. As many tests as possible shall be arranged together. Six copies of the Contractor's test report and test sheets shall be supplied to AEGCL for approval.

Measuring apparatus shall be approved by AEGCL and if required shall be calibrated at the expense of the Contractor at an approved laboratory.

The Contractor shall be responsible for proper testing of the work completed or plant or materials supplied by a sub-contractor to the same extent as if the work, plant or materials were completed or supplied by the Contractor himself.

All apparatus, instruments and connections required for the above tests shall be provided by the Contractor, but AEGCL may permit the use for the tests on site, any instruments and apparatus which may be provided permanently on site as part of the contract works conditional upon the Contractor accepting liability for any damage which may be sustained by such equipment during the test.

The contractor shall supply suitable test pieces of all materials as required by AEGCL. If required by AEGCL, test specimens shall be prepared for check testing and forwarded at the expense of the Contractor to an independent testing authority selected by AEGCL.

Any costs incurred by the Employer in connection with inspection and re-testing as a result of a failure of the subject under test, or damage during transport, or erection on site before take-over by the Employer, shall be to the account of the Contractor.

No inspection or lack of inspection or passing by AEGCL of work, plant or materials, whether carried out or supplied by the Contractor or sub-contractor, shall relieve the Contractor from his liability to complete the Contract Works in accordance with the Contract or exonerate him from any of his guarantees.

The above specification are general guidelines. If specific requirement is made for individual items, that will supersede the above details.

7.22 FIRE PRECAUTIONS

All apparatus, connections and cabling shall be designed and arranged to minimise the risk of fire and any damage which might be caused in the event of fire. When cabling is carried out as part of this Contract the Contractor shall be responsible for sealing all holes in floors, walls, roofs etc. through which the cabling may pass.

The work procedures that are to be used during the erection shall be those which minimise fire hazards to the maximum extent practicable. Combustible materials, combustible waste and rubbish shall be collected and removed from the site at least once each day. Fuels, oils and volatile or flammable materials shall be stored away from the construction site and equipment and material stores in appropriate safe containers.

All Contractors' supervisory personnel and at least ten percent all of workers shall be trained for fire-fighting and shall be assigned specific fire protection duties. At least ten percent of all personnel assigned to site at any one time shall be trained for firefighting.

The contractor shall provide sufficient fire protection equipment of the types and sizes for the ware-houses, office temporary structures, labour colony area etc. Access to such fire protection equipment shall be easy and kept open at all time.

7.23 PACKING, SHIPPING AND TRANSPORT

The Contractor shall be responsible for the packing, loading and transport of the plant and equipment from the place of manufacture, whether this is at his own works or those of any Contractor, to Site, and for off-loading at site.

All apparatus and equipment shall be carefully packed for transport by air, sea, rail and road as necessary and in such a manner that it is protected against tropical climate conditions and transport in rough terrain and cross-country road conditions. The method of packing shall provide complete protection to all apparatus and equipment during transport and storage at site in heavy rain. The method of packing shall provide adequate protection to main items of plant and those parts contained within and attached without, for transportation.

Precautions shall be taken to protect parts containing electrical insulation against the ingress of moisture.

All bright parts liable to rust shall receive a coat of anti-rusting composition and shall be suitably protected. The machined face of all flanges shall be protected by means of a blank disc bolted to each face.

Where appropriate all parts shall be boxed in substantial crates or containers to facilitate handling in a safe and secure manner. Each crate or container shall be marked clearly on the outside of the case to show “TOP” and “BOTTOM” positions with appropriate signs, and where the mass is bearing and the correct position for slings. Each crate or container shall also be marked with the notation of the part or parts contained therein, contract number and port of destination. It shall be the Contractor's responsibility to dispose of all such packing.

Any damage due to defective or insufficient packing shall be made good by the Contractor at his own expense and within reasonable time when called upon by AEGCL to do so. Four (4) copies of complete packing lists showing the number, size, marks, mass and contents of each package shall be delivered to AEGCL immediately after the material is despatched.

The Contractor shall inform himself fully as to all relevant transport facilities and requirements and loading gauges and ensure that the equipment as packed for transport shall conform to these limitations. The Contractor shall also be responsible for verifying the access facilities specified.

The Contractor shall be responsible for all costs of repair or replacement of the equipment, including those incurred by the Employer, arising from damage during transport, off-loading or erection on site, until take-over by the Employer.

The Contractor shall be responsible for the transportation of all loads associated with the contract works and shall take all reasonable steps to prevent any highways or bridges from being damaged by his traffic and shall select routes, choose and use vehicles and restrict and distribute loads so that the risk of damage shall be avoided. Any cost of claim towards damages, if any, caused to Bridges and Highways during transportation of the materials shall be borne by the contractor.

7.24 ERECTION MARKS

Before leaving the Contractor's Works all apparatus and fittings shall be painted or stamped in two places with a distinguishing number and/or letter corresponding to the distinguishing number and/or letter on an approved drawing and material list. All markings shall be legible; weatherproof tags, where used, shall be durable, securely attached and duplicated.

The erection marks on galvanised material shall be stamped before galvanising and shall be clearly legible after galvanising.

7.25 SPECIAL TOOLS & EQUIPMENTS

A complete set of spanners shall be supplied for each station to fit every nut and bolt head on the apparatus supplied under this Contract, together with all special tools required for the adjustment and maintenance of the equipment. These tools shall be mounted in a lockable cabinet at each substation, also to be provided under this Contract. Eye bolts which have to be removed after use shall be accommodated in the cabinets.

Spanners and other maintenance equipment provided under the Contract shall not be used for the purpose of erection of the contract Works.

Any special devices, slings or tackle necessary for the complete overhaul of the plant shall be handed over to AEGCL in working order on completion of the Contract.

On delivering any or all of these tools to AEGCL, a signature shall be obtained from AEGCL's representative. Any tools not signed for shall be deemed not to have been delivered.

The above specification are general guidelines. If specific requirement is made for individual items, that will supersede the above details.

7.26 RUNWAY BEAMS, EYE BOLTS AND LIFTING TACKLE

Runway beams shall comply with the requirements of BS 2853, or its equivalent, and shall be tested after erection in accordance with this standard and this Specification. The Contractor shall be responsible for the provision of the appropriate test certificates which must be in accordance with Appendix C of BS 2853.

All slings, eye bolts and other lifting tackle provided shall be proof tested to twice the safe working load and suitably marked with embossed labels to show clearly the safe working loads.

CHAPTER 8: ELECTRICAL EQUIPMENT INSTALLATION AND COMMISSIONING

8.1 ELECTRICAL EQUIPMENT INSTALLATION AND COMMISSIONING

8.1.1 SCOPE

The below specification are general guidelines. If specific requirement is made for individual items, that will supersede the below details.

This chapter describes board guidelines for installations, testing and commissioning of electrical equipment. The work shall, however, be carried out strictly as per the instruction of the MANUFACTURER / EMPLPOYER.

8.1.2 CODES AND STANDARDS

The electrical installation work shall comply with the latest applicable standards, regulations, electricity rules and safety codes of the locality where the installation is carried out. Nothing in this specification shall be construed to relieve the CONTRACTOR OF HIS RESPONSIBILITY. If any IS/IEC/ Any Other International standard, is required during the detailed engineering stage, the same shall be provided by EPC without any additional cost.

8.1.3 GENERAL

The CONTRACTOR shall transport the equipments where required in actual position. Erect, assemble all parts of the equipments and test and commission the same. The CONTRACTOR shall furnish all tools, welding equipment, rigging materials, testing equipment, test connections and kits, etc. required for complete installation, testing and commissioning of the items included in the contract work. The EMPLOYER may engage specialist Employer to supervise the installation, testing and commissioning of their equipment. The CONTRACTOR shall extend full co-operation to these Employers and carry out the works as per their instructions. The CONTRACTOR'S work shall include minor rewiring modifications as may be necessitated during commissioning. Providing such assistance shall be deemed to be included in the CONTRACTOR'S basic scope. The CONTRACTOR shall co-operate through the EMPLOYER with other contractors at site, in all matters of common interest, so as not to abstract operation of others and to ensure the safety of all personnel and works covered under this specification. It will be the CONTRACTORS responsibility to assist the OWNER to obtain approval/ clearance from local statutory authorities including electrical inspector, wherever applicable, for conducting any work or for installation carried out which comes under the purview of such authorities. The work shall be carried out strictly as per the instructions and layout drawings of the EMPLOYER/ manufacturer. In case of any doubt/ misunderstanding as to correct interpretation of the drawings or instructions, necessary clarifications shall be obtained from the EMPLOYER. The CONTRACTOR shall be held responsible for any damage to the equipment consequent to not following the MANUFACTURER'S instructions correctly. All necessary drawings/MANUFACTURER'S equipment manuals will have to be arranged by the contractor as this is a Turn-key contract.

All thefts of equipment/component parts till the including executed portion handed over to the EMPLOYER shall be made good by the CONTRACTOR.

The CONTRACTOR shall have a separate cleaning gang to clean all equipment during erection and as well as the work area and the project site at regular intervals to the satisfaction of the EMPLOYER. In case the cleaning is not to the Employer's satisfaction, he will have the right to carry out the cleaning operations and any expenditure incurred by the OWNER in this regard will be the CONTRACTOR'S account.

In order to avoid hazards to personnel moving around the equipment such as switcher etc. which is kept charged after installation before commissioning, such equipment shall be suitably cordoned off to prevent any one accidentally going near it.

Safety of the Contractor's personnel engaged in erection and commissioning job will be Contractor's responsibility.

The CONTRACTOR shall carry out touch-up painting on any equipment indicated by the EMPLOYER if the finish paint on the equipment is soiled for marred during installation handling.

The CONTRACTOR shall ensure workmanship of good quality and shall assign qualified supervisors/Employers and competent labour who are skilled, careful and experienced in their several trades in similar works. The EMPLOYER shall reserve the right to reject non-competent persons employed by the CONTRACTOR, if the workmanship is not of good order.

It shall be the responsibility of the CONTRACTOR to obtain necessary Licence/ Authorisation, Permit for work from the Licensing Board of the Locality/ state where the work is to be carried out. The persons deputed by the CONTRACTOR'S firm should also hold valid permits issued or recognized by the Licensing Board of the locality/State where the work is to be carried out. A list of the personnel engaged in erection and commissioning work should be submitted to the Employer before commencement of the work.

8.2. INSTALLATION WORK SCOPE

Equipment shall be installed in neat, workmanlike manners so that it is level, plump, square and properly aligned and oriented. Tolerances shall be established in the Manufacturer's drawings or as stipulated by the EMPLOYER. No equipment shall be permanently bolted down to foundation or structure until the alignment has been checked and found acceptable by the EMPLOYER.

Care shall be exercised in handling to avoid distortion to stationary structures, the marring of finish, or damaging of delicate instruments or other electrical parts. Adjustment shall be made as necessary to the stationary structures for plumb and level, for the sake of appearance or to avoid twisting of frames, binding of hanged members, etc.

The CONTRACTOR shall move all equipment into the respective building through the regular doors or floor opening provided specially for lifting the equipment.

All external cabling including end connections and earthling shall also be carried out.

8.2.1 POWER AND INSTRUMENT TRANSFORMERS

Physical inspection on receipt, storage, installation, testing and commissioning of transformers shall be in accordance with the specified code of practice and Manufacturer's instructions.

Transformer may be delivered without oil filled with inert gas and without bushings and external mounted accessories. As applicable, the CONTRACTOR shall.

a) Assemble the transformers with all fittings such as bushings, cooler banks, radiator, conservators, valves, piping, cables boxes, marshalling boxes OLTC, cooling fans/pumps, etc.

b) Arrange for vacuum and oil filtration of the transformers. Oil filtration shall be done as per the standard practice. Oil tanker in this effect are to be used and filtration to be done while the oil is inside the tanker. On getting the standard value of the oils the same shall be pushed into the main tank and other portion of the transformer. Final filtration to be done after entire oil is filled in the transformer. Prior to that vacuum treatment of the tank of the transformer with the windings are to be taken up.

c) Provide wedges/clamps to rigidly station all transformers on rails.

d) Connect up the transformer's terminals.

e) Lay and terminate cables/ conduits between all the accessories mounted on the transformer tank/cooler and the transformer-marshalling kiosk and RTCC panels etc.

f) Pre commissioning checks shall be carried out as per relevant standards and Employer's instructions.

The CONTRACTOR shall arrange the oil filtration equipment.

Care shall be taken during handling of insulating oil to prevent ingress of moisture or foreign matter. In the testing, circulating, filtering or otherwise handling of oil, rubber hoses shall not be used, circulation and filtering of oil, the heating of oil by regulated short-circuit current during drying runs and sampling and testing of oil shall be in accordance with the MANUFACTURER'S instructions and specified Code of Practice.

8.2.2 SWITCHGEAR, CONTROL/ RELAY PANELS

Switchgears and control relay panels/desks shall be installed in accordance with specified Code of Practice and the Manufacturer's instructions. The switchgear panels shall be installed on finished surfaces or concrete or steel sills. The CONTRACTOR shall be required to install and align and channel sills which form part of the foundations. In joining shipping sections of the switchgear/panels /control centers together with adjacent housing or panes sections provided shall be bolted together after alignment has been completed. Power bus, enclosures, ground and control splices of conventional nature shall be cleaned and bolted together, being drawn up with torque wrench of proper size or by other approved means. Tape or compound shall be applied where called for by the MANUFACTURER'S drawings.

The CONTRACTOR shall take utmost care in handling instruments. Relays and other delicate mechanisms. Wherever the instruments and relays are supplied separately, they shall be mounted only after the associated control panel/desks have been erected and aligned. The blocking materials/mechanism employed for the safe transit of the instruments and relays shall be removed after ensuring that the panels/desks have been completely installed and no further movement of the same would be necessary. Any damage to relays and instruments shall be immediately reported to the EMPLOYER and shall have to be rectified at contractor's cost.

Pre-commissioning checks on relays have to be carried out on all relays in accordance with manufacturer's instruction and in presence of Employer.

8.2.3 BATTERY AND CHARGERS

Installation and testing of battery and battery chargers shall be done in strict compliance with the manufacturer's instructions. Each cell shall be inspected for break ate and condition of cover seals as soon as received at site. Each cell shall be filled with electrolyte in accordance with the MANUFACTURER'S instructions. Battery shall be set up on racks as soon as possible after receipt, utilizing lifting devices supplied by the MANUFACTURER. The cells shall not be lifted by the terminals. Contact surfaces of battery terminals and inter-cell connectors shall be cleaned, coated with protective grease and assembled. Each connection shall be properly tightened. Each cell shall be tested with hydrometer and results logged. Freshening charge, if required, shall be added. When turned over to the EMPLOYER, the battery shall be fully charged and electrolyte shall be at full level and of specified specific gravity.

Battery shall be put in commercial use only after carrying out charge/discharge cycle as per Manufacturer's instruction.

8.3 SWITCHYARD

The CONTRACTOR shall carry out switchyard installation as required as per approved plan and elevation drawings of switchyard showing bus bar configurations, sizes, tensions, insulator details, etc. All equipment including connectors (unless otherwise specified) will be supplied by the VENDOR. The bus bar arrangement shall be:

One & Half Breaker – 400kV (both AIS & GIS)

Main Bus-1 and Main Bus-2 (Two Main) / (for GIS) (Double Main cum Transfer / Double Main and Transfer for AIS)

Main Bus-1 and Main Bus-2 (Two Main) (for GIS) Main bus and transfer bus - 132 KV side (for AIS).

Single Bus with Sectionalizer for 33kV AIS

The CONTRACTOR shall install complete set of bus bars and all bays' conductors complete with tension with tension suspension insulator strings, bus-post insulators, equipment connections, bus bar connections to equipment, lightning shield wires including down comers up to a height of 1000 mm. From ground level where they shall be connected to the Employer's test links.

Installation work of breakers and isolators shall include adjustment/ alignments necessary for proper operation of circuit breakers, isolators and their operating mechanisms. All insulators and bushings shall be protected against damage during installation. Insulators and bushings damaged due to negligence or carelessness of the CONTRACTOR shall not be in any way accepted and shall be replaced by him at his expense.

General requirements of Installation of Cabling:

i) The supplier shall install, test and commission the cables. Cables shall be laid on cable trays and supports, in conduits and doctor or bare on walls, ceiling, etc. as required. The supplier's scope of work includes laying, fixing, jointing, bending and terminating cables. The supplier shall also supply necessary materials and equipment required for jointing and terminating of cables. The supplier shall prepare detailed layout drawing for cable trenches, cable tray layouts for approval by Employer and construct cable routes strictly according to these drawings.

ii) Sharp bending, twisting and kinking of cables shall be avoided. The bending radius for various types of cables shall not be less than those specified by cable manufacturer.

iii) In each cable run, some extra length shall be kept at a suitable point to enable one or two straight through joints to be made. Should the cable develop fault at a later date.

iv) Cable joints in the middle of the run for control cables will not be an accepted.

v) All cable terminations shall be made in a neat. Workmanlike manner. Terminations shall be made for each type of wire or cable in accordance with instructions issued by cable manufacturers and the Employer.

vi) Metal sheath and Armour of the cable shall be bounded to the earthing system of the sub-station.

8.3.1. GENERAL REQUIREMENTS OF INSTALLATION FOR CONDUITS, PIPES AND DUCTS.

i) The supplier shall supply and install conduits pipes (PVC thick but flexible suitable for taking inside the roof and walls) and ducts as necessary for the lighting system. All accessories/fittings required for making installation complete. Including but not limited to ordinary and inspection tees and elbows, check nuts, make and female reducers and enlargers, wooden plugs, caps, squat headed male plugs, nipples, gland sealing fittings, motion boxes, pull boxes, conduit outlets, outlet boxes, splice boxes, terminal boxes, glands, gaskets and box covers, saddles and all steel supporting work shall be supplied. Conduit fittings shall be of the galvanized one. Flexible metallic conduits shall be used for termination of connections to equipment such as motors or other apparatus to be disconnected at periodic intervals.

ii) Conduits (thick and flexible PVC) and accessories shall be adequately protected against mechanical damage as well as corrosion.

8.3.2. GENERAL REQUIREMENTS OF INSTALLATION FOR EARTHING AND LIGHTNING PROTECTION SYSTEMS

8.4. SCOPE OF INSTALLATION

i) The supplier shall install steel conductors (GI flats) and braids, as required for system and individual equipment earthing. All work such as cutting, bending, supporting, painting coating drilling, brazing/soldering/welding, clamping, bolting and connection on to structures, equipment frames, terminals, rails or other devices shall be in the scope of work. All incidental hardware and consumables such as fixing cleats/clamps. Anchor fasteners, lugs, bolts, nuts, washers, bituminous compound, anticorrosive paints as required for the complete work shall be deemed to be included as part of the installation work.

ii) The quantities, sizes and material of earthing conductors and electrodes to be installed and routes of the conductors and location of the electrodes shall be as per specification mentioned elsewhere and approved drawings for the optimal capacity of the Sub-station taking the future requirement in to account.

iii) The scope of installation of earth conductors in outdoor areas, buried in ground shall include excavation in earth at least up to 700 mm. Deep and 450 mm, wide (unless otherwise stated), brazing/welding as required of main grid conductor joints as well as risers of 500 mm. Length above ground at required locations and back filling. Backfilling material to be placed over buried conductor shall be free from stones and other harmful mixtures. Backfill shall be placed in layers of 150 mm, uniformly spread along the ditch and tempered utilizing pneumatic tempers or other approved means.

iv) The scope of installation of earth connection leads to equipment and risers on steel structures/walls shall include laying the conductors, welding/ cleating, at specified intervals, welding/brazing to the main earth grids risers, bolting at equipment terminals and coating welded/brazed joints by bituminous paint. Galvanized conductors shall be touched up with zinc rich paint, where holes are drilled at site for holding to equipment/ structure.

v) The electrodes shall be installed either directly in earth or in constructed earth pits as shown in approved drawings.

vi) The scope of installation of lightning conductors on the roof of buildings shall include laying, anchoring, fastening and cleating of horizontal conductors, grouting of vertical rods where necessary, laying, fastening/cleating/welding of the down comers on the walls/columns of the building and connection to the test links above the ground level.

vii) The scope of installation of the test links shall include mounting of the same at specified height on wall/column by suitable brackets and connections of the test link to the earth electrodes.

8.4.1 Earthing connections:

i) All connections in the main earth conductors buried in earth/concrete shall be welded/brazed type. Connection between main earthing conductor and earth leads shall also be of welded/brazed type.

ii) Welding and brazing operations and fluxes/alloys shall be of approved standards.

iii) All connections shall be of low resistance. Contact resistances shall also be minimum.

iv) All bi-metallic connections shall be treated with suitable compound to prevent moisture ingress.

8.4.2 Earth Electrodes:

i) Electrodes shall as far as practicable, be embedded below permanent moisture level.

ii) Pipe electrodes shall be housed in test pits with concrete covers for periodic testing of earthing resistively pipe electrodes in test pits shall be convenient for inspection, testing and watering.

iii) Earth pits shall be treated with salt, charcoal and bentonite where ever required.

iv) Soil, salt and charcoal placed around the electrode shall be finely graded free from stones and other harmful mixtures. Backfill shall be placed in the layers of 250 mm. Thick uniformly spread and compacted. If excavated soils are found unsuitable for backfilling, the contractor shall arrange for a suitable soil from outside.

8.5. TESTING OF EARTHING SYSTEM

The Supplier shall ensure the continuity of all conductors and joints. The Purchaser may ask for earth continuity tests, earth resistance measurements and other tests, which in his opinion are necessary to prove that the system is in accordance with the design, specifications and code of practices. The supplier shall have to bear the cost of all such tests.

8.5.1. GENERAL REQUIREMENTS OF INSTALLATION FOR LIGHTNING SYSTEM AND POWER RECEPTACLES

i) The supplier shall supply, install, test and commission complete lighting system and power receptacles in accordance with relevant Standards. Concealed conduit wiring (thick flexible PVC pipes suitable for taking inside the roof and walls) shall be adopted for the control building.

ii) Wiring shall be colour-coded so as to enable easy identification of phase and neutral conductors, and DC wire (colour-coded as follows – white – phase wire, black – neutral wire, grey / DC wires.)

iii) There shall be switch on each live conductor of supply mains at the point of entry. The wiring throughout the installation shall be such that there is no break in neutral wire in the form of switch or fuse unit.

iv) Fixtures shall be ground by 1.5sq mm. flexible PVC copper wires (green colour) and taken to earth strips.

v) All fixtures, associated accessories, conduits, wires, junction boxes, cables, switches, switch boxes, etc. required for complete wiring of the lighting system as per approved drawings shall be supplied.

8.5.2. TESTING AND COMMISSION

All checks and tests as per the Manufacturer’s drawings/manuals, relevant code of installation/erection practices and commissioning checks for various types of equipment e.g. transformers, breakers, isolators, CTs, PTs, motors, relays, meters, etc. shall be carried out by the CONTRACTOR as part of the installation work.

The owner may ask for such additional tests on site as in his opinion are necessary to determine that the works comply with the specification, Manufacturer’s guarantee/instructions or the applicable code of installation. The CONTRACTOR shall carry out such additional tests also.

The CONTRACTOR shall perform operating tests on all switchgear and panels to verify operation of switchgear/panels and correctness of the inter-connections between various items of the equipment. This shall be done by applying normal AC or DC voltage to the circuits and operating the equipment for functional checking of all control circuits e.g. closing, tripping, control interlock supervision and alarm circuits. All connections in the switchgear shall be tested from point for possible ground or short circuit.

Insulation resistance tests shall be carried out by following rating megger:

a) Control circuits up to 220 V : By 500 V Megger

b) Power circuits, busbars : By 5000 Motor
connections for 132 KV. Operated Megger.

c) Power circuits, busbars : By 5000 V Motor
connections above 220 KV. Operated Megger.

The Employer's authorized representative shall be present during every test as called for by the EMPLOYER. The CONTRACTOR shall record all test values and furnish the required copies of the test data to the EMPLOYER. Electrical circuits and equipments shall be energized or used at nominal operating voltage only after such reports have been accepted as satisfactory by the EMPLOYER.

8.6. COMPLETION CHECKS

a) Name plate details according to approved drawings/ specifications.

b) Any physical damage or defect and cleanliness.

c) Tightness of all bolts, clamps and connections

d) Oil leakages and oil level.

e) Condition of accessories and their completeness.

f) Clearances.

g) Earthing connections.

h) Correctness of installation with respect to approved drawings/ specifications.

i) Lubrication Moving parts.

j) Alignment.

k) Correctness and condition of connections.

8.6.1 COMMISSIONING TESTS

a) Insulation resistance measurement of equipment, accessories, cabling/ wiring. etc.

b) Dielectric tests on equipment, accessories, cabling/wires. etc.

c) Phase sequence and polarity.

d) Voltage and current ratios.

e) Vector group.

f) Resistance measurement of winding. Contacts, etc.

g) Continuity tests.

h) Calibration of indicators, meters, relays. etc.

i) Control and interlock checks.

j) Settings of equipment accessories.

k) Checking of accuracy/error.

l) Checking of operating characteristics, pick/up voltages and currents. Etc.

m) Operational and functional tests on equipment, accessories, control schemes, alarm/ trip/ indication circuits, etc.

n) Measurement of guaranteed/approved design values including lighting levels, earth resistance measurements, etc.

o) Complete system commissioning checks.

CHAPTER 9: TECHNICAL SPECIFICATIONS OF XLPE INSULATED COPPER CONTROL AND POWER CABLE

This technical specification intends to cover the following:

Technical specifications for design, engineering, manufacturing, inspection, testing at manufacturer's works, packaging and delivery by road (properly packed in non-returnable steel drums), various sizes of copper conductor, XLPE insulated, voltage upto and including 1100 Volts, extruded PVC inner sheathed, extruded FRLS PVC outer sheathed, GI round wire armoured cables, suitable for solidly grounded system. The cables shall confirm to IS 7098-Part 1 with latest amendments. For cable list refer Table-1 (Sl. no. 1.1 to 1.19).

Note:

1. Tenders will only be considered from the cable manufacturers and any one supplier to whom manufacturer can authorize. The bidder shall have adequate experience of at least 5 years in manufacturing of LT/MV & HT cables and field proven experience of min 5 years.
2. Copper samples from the finished cable drums shall be tested at any 3rd party NABL accredited lab to ensure its purity.
3. The following document shall be attached with technical part of the bid:
    i. Duly filled & Signed copy of Annexure-I, II, III & IV
    ii. Deviation sheet, if any

Table 1

Sl. No	Power Cable
1	3C X 2.5 Sq.mm, Copper Power Cable Type: 2XWY
2	4C X 2.5 Sq.mm, Copper Power Cable Type: 2XWY
3	3C X 4 Sq.mm, Copper Power Cable Type: 2XWY
4	4C X 4 Sq.mm, Copper Power Cable Type: 2XWY
5	3C X 6 Sq.mm, Copper Power Cable Type: 2XWY
6	4C X 16 Sq.mm, Copper Power Cable Type: 2XWY

Sl. No	Power Cable
7	3C X 10 Sq.mm, Copper Power Cable Type: 2XWY
8	4C X 10 Sq.mm, Copper Power Cable Type: 2XWY
9	3C X 16 Sq.mm, Copper Power Cable Type: 2XWY
10	2C X 16 sqmm
11	2CX50 sqmm
12	3.5 C X 35 sqmm
13	3.5 CX70 sqmm
14	3.5 C X 95 sqmm
15	3.5 C X 150 sqmm
16	3.5 C X 300 sqmm
17	1 C X 1000 sqmm
18	2C X 6 sqmm
Control Cable(Copper)	
1	2 C, 1.5mmsq
2	4C, 2.5 sq mm
3	5C, 2.5 sq mm
4	7C, 1.5 sq mm
5	7C, 2.5 sq mm
6	10 C, 2.5 sq mm
7	12 C, 2.5 sq mm
8	12 C,1.5 sq mm
9	14 C, 2.5 sqmm
10	17 C,1.5 sqmm
11	19 C,1.5 sqmm
12	19C,2.5 sqmm

Technical Specifications for 1.1 kV grade, Copper conductor, Power and Control cable

This section covers the technical specifications for design, engineering, manufacturing, inspection, testing at manufacturer's works, packaging and delivery by road (properly packed in non-returnable steel drums), 1.1KV grade, Multi-stranded Copper conductor, XLPE insulated, extruded PVC inner sheathed, GI round-wire armoured, extruded FRLS PVC ST2 outer sheathed. Power Cables and Control Cables for effectively grounded system, conforming to the latest revisions of IS: 7098 (Part –I), 1988 & as per the technical specifications attached herewith.

9.1 STANDARDS

The design, manufacture and testing of the cable shall comply with the latest editions/amendments of the following Indian Standards, unless otherwise specified. Equipments complying with equivalent standards shall also be acceptable.

a.	IS-7098, 1998 (Part-I)	:	Cross linked polyethylene insulated PVC sheathed cables for working voltages upto 1100V.
b.	IS-3961	:	Recommended current ratings for Cables
c.	IS 8130-1984	:	Specification for conductors for insulated electric cables and flexible cords.
d.	IS-3975, 1999	:	Low Carbon galvanized steel wires, formed wires & tapes for armouring of cables
e.	IS-4759	:	Specifications for Hot dipped galvanized coating on round steel Wires
f.	IS-5831	:	PVC insulation and sheath of electric cables.
g.	IS-10418	:	Drums for electric cables.
h.	IS-10810	:	Method of test for cables.

9.2 SERVICE CONDITION

Service Condition shall be as per General Technical Requirements (GTR).

9.3 DESIGN AND CONSTRUCTION PERTICULARS

9.3.1. General

The cables supplied under this specification shall be adequate insulated to operate continuously at the specified voltage with a high degree of safety and reliability throughout the life of the cables. The sheathing material shall be high quality PVC based compound. The construction of cable shall be as per IS: 7098 (Part I) – 1988.

Cable shall be designed and manufactured to prevent damage during transportation, installation & operation under all climatic & operating condition.

9.3.2. Technical parameters

i.	Quantity	: Refer Table-1
ii.	Packaging	Steel drum packaging, each having single length cable ≥ 500 metres. (for size less than1000sqmm.).
iii.	Cable Type	A2XWY/ 2XWY (refer Table-1 for details)
iv.	No. of Cores	Shall be decided during detailed engineering (Cable sizing calculation)
v.	Voltage Level	1.1Kv
vi.	System Grounding	Solidly Grounded

vii. Nominal System voltage : 415V ±10%

viii. Nominal System Frequency : 50 Hz

ix. Maximum conductor temperature at rated current : 90 deg C

x. Maximum conductor temperature at Short-circuit : 250 deg C

xi. Conductor Conductor Material : H4-Grade Aluminium of purity > 99.6% Electrolytic grade Copper, Purity > 99.97%

xii. Conductor type : Stranded with number of strands as per IS 8130 (Part-I) 1984

xiii. Insulating material : Cross-Linked-Polyethylene (XLPE) Compound.

xiv. Core Identification Strips : Red, Yellow, Blue & Black (for neutral)

xv. Material of Inner Sheath : FRLS, PVC ST-2 Compound

9.4 Conductor

COPPER

The conductors shall be made from high conductivity copper rods complying with IS: 613-1964. The conductor material used shall be electrolytic grade with high purity. Two sample conductor randomly selected from finished lot of cables, shall be tested for its purity at any 3rd party NABL accredited lab. The conductors shall conform to appropriate dimensions, resistance and number of wire in the conductor (number of strands) as given in IS 8130 (Part I): 1984.

9.5 Insulation

The insulating material for power and control cables shall be extruded cross linked polyethylene (XLPE) compound as per IS-7098(Part-I)-1988. The minimum thickness of insulation shall not be less than the values specified in Table-2 of IS-7098 (Part-I)-1988. No negative tolerance shall be applicable for the thickness. The insulation of the cable shall be designed and manufactured for the specified system voltage. The manufacturing process shall ensure that insulation shall be free from voids. The insulation shall withstand mechanical and thermal stress under steady state and transient operating conditions. The cores shall be identified as per the following colour scheme:

3-Core - Red, Yellow & Blue

3 ½ or 4-Core - Red, Yellow, Blue & Black

9.6 Inner Sheath

The inner sheath shall be extruded FRLS PVC, Type ST2, compatible with thermal rating of insulation conforming to IS-6380-1984. The sheath shall have adequate thickness, mechanical strength and elasticity, as specified in IS 5831. The material shall be soft thermoplastic type, applied by extrusion method. The thickness of the inner sheath shall be as per IS: 7098 (Part I) and the color of the inner sheath shall be Grey. The inner sheath shall be so formed that it fits closely on the laid up cores and could be easily removed without damaging insulation. One or more layer of proofed plastic tape shall be provided over the laid up core before extrusion.

9.7 Outer Sheath

Extruded outer sheath shall be provided over the armouring. The material used for sheathing shall be FRLS PVC sheath, Type ST-2 base compound conforming to IS 1554/ IS 5831 for power and control cable. The outer sheath shall be so formed that it fits closely on the laid up armour and could be easily removed without damaging the intermediate sheath and insulation. The colour of the outer sheath shall be black. The thickness of outer sheath shall be in accordance with the IS 1554 (Part-I)-1988. Suitable additives shall be added to prevent attack by rodents and termites. All serving must be given anti-termite treatment.

Cables shall have suitable fillers laid up with the conductor to provide a substantially circular cross section before the sheath is applied. Fillers shall be suitable for the temperature of the cable and compatible with the insulating material. The material shall be of the best quality and workmanship. The fillers and sheath material shall be non-hygroscopic. All materials shall be new, unused and of the finest quality.

9.8 TESTS

All the tests specified below shall be carried out in accordance with the Indian Standards by the manufacturer in the presence of Purchaser’s representative. If the cable fails to pass the test specified, the Purchaser shall have the option to reject it. Shipping release shall be obtained from the Purchaser's representative. The Purchaser, however reserves the right to waive off the inspection.

The tests at works shall include electrical, mechanical and hydraulic tests in accordance with the appropriate clauses of Statutory Regulation, relevant codes and standards, in addition any test called for by the Purchaser or his representative to ensure that the equipment being supplied fulfils the requirement of the specification.

For test not covered by any code or specifically mentioned in this specification, the test procedures are to be agreed with the Purchaser.

9.9 Pre Dispatch Inspection

The manufacturer shall be given at least 15 days advance notice prior to the commencement of testing, so that Purchaser’s representative can plan to witness the tests.

All the tests indicated in the test clause of this specification shall be carried out in the presence of Purchaser’s representative by the manufacturer and shall provide all the facilities and equipment for testing.

Six copies of the Test Certificate shall be furnished to the Purchaser for approval prior to dispatch of cables from factory.

Visual check to conform the details given in this specification is to be done. In addition to the above, the general workmanship of the cable drums and cables laid in drums shall be checked.

Manufacturer shall have proper test set up for testing all the routine tests & type tests on finished cables as per IEC.

List of type tests mentioned in the tender specifications shall be conducted on four drum irrespective of type test certificates given or not.

9.10 Type Test

Type tests on four randomly selected cable drums will have to be conducted in the presence of the department’s representative. The test samples will be taken from finished cables. This test shall be in accordance to IS: 7098, Part-1,1988.

a. Test on Conductor

- Annealing test for copper conductors
- Tensile test for aluminium conductor
- Wrapping test for aluminium conductor
- Conductor Resistance Test

b. Test on Insulation

- Physical dimension measurement
- Tensile strength and elongation at break

- Hot set test
- Shrinkage test
- Ageing in air oven
- Water absorption test

c. Test on round Armour

- Physical dimension measurement
- Tensile strength
- Elongation at break
- Torsion test for round wires
- Winding test for firmed wire
- Mass of zinc coating.
- Uniformity of zinc coating
- Resistivity measurement, Resistance test for armour

d. Test on Sheath

- Physical dimension measurement
- Tensile strength & Elongation at break test
- Ageing in air oven
- Loss of mass in air oven
- Shrinkage test
- Hot deformation test
- Heat shock test
- Thermal stability test

e. Insulation Resistance Test

f. High Voltage Test at room temperature

g. Volume resistivity at room temperature & at 90^{o} C. (IS-10810-Part 43)

h. Flammability test

i. *Test requirement of FRLS inner and outer sheath*

The inner and outer sheath of cables shall meet the following test requirements related to flame retardant, low smoke emission, low acid and toxic gas emission. The BIDDERs shall have proper test apparatus to conduct all the relevant tests as per the applicable standards:

Flame retardant test on single cable.

- Oxygen Index Test

The critical oxygen index value shall be minimum 29 when tested at 27+2ºC as per ASTMD-2863

- Temperature index test

  Temperature index value shall be minimum 250ºC at oxygen index of 21 when tested as per NES 715.

- Flammability test

- Smoke Density Test

  The cables shall satisfy the tests conducted to evaluate the percentage obscuration by smoke in an optical system placed in the path of the smoke. The maximum smoke density rating shall not be more than 60% when tested as per ASTM-D-2843.

- Acid Gas Generation test (halogen acid gas evolution)

  The hydrochloric acid generation when tested as per IEC 754-1 shall be less than 20% by weight.

- Test for specific optical density of smoke
- Anti termite and rodent property test

The sequence of electric tests shall be as per the relevant Indian/International standards. The Bidder shall submit the sequence of tests for the approval of the purchaser before conducting the tests. A copy of the adopted standard shall also be supplied.

9.11 Routine Test (On each drum)

The following routine tests shall be carried out by the Manufacturer on each and every length of the cable in the presence of Purchaser's representative at manufacturer's works.

a. Resistance test for conductors

b. Insulation resistance test

c. High voltage test

9.12 Conductor purity test

Two samples of aluminium and copper shall be taken from any of the finished set of cables at random and the sample shall be tested for its purity at a NABL accredited lab.

Qualifying Criteria:

The test results should be within limits as per IS 7098. All the routine tests as per IS 7098 / IEC shall be conducted and passed as per the limits given in the standards.

All the bought out certificates will be verified and the test results shall be as per respective standards.

9.13 Identification

The following details shall be marked sequentially for each meter run length of the cable by non-erasable embossing on the outer sheath:

a. Reference to Indian Standard
b. Name of the manufacturer/ Trade Name
c. Name of the project:
d. Configuration of the cable: viz. Voltage grade, no. of Core, Sq. mm, A2XWY/2XWY/YWY / YY as applicable
e. Year of manufacturing
f. Sequential marking of running meter length

   The running length of the cable shall be identified at regular intervals of one meter (Increasing order from inner end to outer end of the cable)

9.14 PACKAGING

Each drum shall consist of single length cable ≥ 500 metres (for sizes less than 1000sqmm.).

The cable shall be wound on *non-returnable steel drums* of suitable size, packed and marked.

· Packing shall be sturdy to protect the cable from any injury during transportation, handling and storage. The cut ends of the cable shall be sealed by means of non-hygroscopic sealing material preferably Heat shrinkable end caps.

· One end of the cable shall be brought out of the drum and suitably clamped to the drum flange with proper mechanical protection. Location of the other end may be marked on the drum.

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· The cable shall be placed on drums in such a manner that it will be protected from injury during transit. Each end of the cable shall be firmly and properly secured to the drum. No undue stress shall appear on cables when laid on drums.

· The cable drum shall carry the following information stencilled on a metallic label, securely attached to each end of the drum:

i. Reference to the Indian standard
ii. Manufacturer’s name, brand or trade mark
iii. Type of cable and voltage grade
iv. No. of cores
v. Nominal cross-sectional area of conductor
vi. Cable code

vii. Length of cable on drum

viii. No. of lengths on reel, drum or coil (if more than one)

ix. Gross weight

x. Country of manufacture

xi. Year of manufacture

xii. Direction of rotation of drum (an arrow)

xiii. ISI certification mark

9.15 PREFERRED MAKE

POLYCAB/KEI/KEC or reputed brand possessing system certification of ISO 9001:2008, ISO14001:2004, OHSAS18001:2007 & EN 16001-2009 and product certifications IS: 7098 (Part-I), CE, UL etc. Quotations without these certification details will not be considered for technical evaluation.

Preferred make of bought out material:

a.	Aluminium for Conductor	:	Hindalco/Balco/Nalco or any other approved make at the time of detailed engineering.
b.	Copper for Conductor	:	Hindustan Copper/Hindalco or any other approved make at the time of detailed engineering
c.	XLPE compound of Insulator	:	Dow/Borealis at the time of detailed engineering

9.16 GUARANTEE

All the cables shall be guaranteed against faulty material, defective design & poor workmanship for a period of 18 months from the date of commissioning. The materials becoming defective during the guarantee period shall be replaced free of cost and the defects arising out of the works shall be rectified free of charge without delay.

ANNEXURE-I

Technical Data Format for 1.1KV, XLPE Insulated, Copper Cable

The tenderer shall furnish all technical details as called for in the following format for all sizes of cables failing which the tender shall be considered as incomplete. *The details shall be furnished separately for all the cables.*

Sl. No.	Particulars	Details
A	Cores	
1	No. of cores	
2	Nom Area of conductor in sq mm.	
3	Voltage Grade	
B	Conductor	
1	Standard Applicable	
2	Material Copper Grade	
3	Purity	
4	Nominal Cross Sectional Area	
5	Form of conductor/circular shaped	
6	No. of strands	
7	Nominal dia of each strand	
8	Temperature co-efficient of resistance at 20 degree celsius	
C	Insulation	
1	Standard Applicable	
2	Material (Mention Type)	
3	XLPE is cured by steam process or Gas process?	
4	Minimum Average Thickness	
5	Tolerance on the smallest of the measured values of thickness of Insulation	

Sl. No.	Particulars	Details
6	Minimum volume resistivity at 27 deg cel	
7	Minimum volume resistivity at 70 deg cel	
8	Colour Scheme for identification of cores	
9	Average Dielectric Strength	
D	Inner Sheath	
1	Standard Applicable	
2	Material for inner sheath	
3	Minimum thickness of inner sheath	
4	Whether extruded	
E	Armour	
1	Standard Applicable	
2	Shape	
3	Size	
4	Material for Armour	
F	Outer Sheath/Overall Covering	
1	Standard Applicable	
2	Material (type)	
3	Whether extruded	
4	Minimum average thickness	
5	Whether anti-termite treatment has been given in the outer sheath	
6	Whether flame retardant low smoke compound added in the outer sheath	
G	Electrical Properties	
1	Maximum DC Resistance of conductor at 20 deg Celsius in ohms/km	
2	Maximum DC Resistance of amour at 20 deg Celsius in ohms/km	

Sl. No.	Particulars	Details
3	Maximum Permissible conductor temperature	
	Under continuous full load	
	Under transient conditions	
4	Loss Tangent at normal frequency	
5	Reactance at maximum operating temperature 50 Hz (ohm/km)	
6	Capacitance at maximum operating temperature 50 Hz (ohm/km)	
7	Total Impedance at maximum operating temperature 50 Hz (ohm/km)	
8	Recommended continuous current rating	
	In Ground at 30 deg C Ground Temperature (A)	
	In Trench/Ducts at 40 deg C (A)	
	In Air at 40 deg C ambient Temperature (A)	
9	Short Ckt Current Rating for 1 sec duration (in KA)	
	Conductor	
	Armour	
10	Minimum volume Resistivity of insulation	
	At 27 °C in Ohm cm	
	At Max operating temperature in Ohm-cm	
11	Approximate AC resistance at max. Operating temperature	
	Phase	
	Neutral	
H	Mechanical Data	
1	Overall Dia of the cable	
2	Dia of the cable under the sheath	
3	Diameter under armour	

Sl. No.	Particulars	Details
4	Diameter over the stranded cores	
5	Wight of cable per km.	
6	Drum length	
7	Tolerance on drum length	
8	Total weight of the drum	
9	Dimension of the drum	
10	Recommended minimum installation radius/ bending radius	
11	Maximum safe pulling force	
12	Whether identification as per clause of the specification is being provided	
13	Whether packing has been done as per clause of the specification	

CHAPTER 10: TECHNICAL SPECIFICATION FOR ISOLATORS (IAS)

10.0 TECHNICAL PARTICULARS OF 400 kV, 220 kV, 132 kV & 33 KV ISOLATOR may be read as:

	Type:	400 kV	220 kV	132 kV	66 kV	33 kV
I	II	III	IV	V	VI	VII
1	Main switch	Centre break/Pantograph	Horizontal Centre break	Horizontal Centre Break	Horizontal Centre break	Horizontal Double break
2	Service		Outdoor			
3	Applicable standard		IS : 9921 / IEC-62271-102			
4	No. of Phases		3 phase			
5	Design Ambient temperature		50°C			
6	Type of operation	Electrically Ganged	Mechanically Ganged			
7	Rated voltage (kV)	In KV	In KV	In KV	In KV	In KV
	a) Nominal	400	220	132	66	33
	b) Maximum	420	245	145	72.5	36
8	Rated current (Amps)	4000	3150	2000	1250	1250
9	Short time current for 1sec.(kA)	63	50	40	31.5	31.5
10	Rated frequency		50 HZ + 5%			
11	System earthing		Effectively earthed			
12	Temperature rise		As per relevant IS/IEC standards			
13	Lightening Impulse withstand voltage (kVp)					
	(a) Across Isolating distance	1425(+240)	1220	750		195
	(b) To earth	1425	1050	650		170
14	1-minute power frequency withstand voltage					
	a) Across Isolating distance	815	605	315		80
	b) To earth	650	460	275		70
15	Switching Impulse withstand voltage (kVp)					
	a) Across Isolating distance	900(+345)	-	-		-
	b) To earth	1050	-	-		-
16	Max. RIV for frequency between 0.5MHz and 2MHz (micro-volt)	1000 at 267kV	1000 at 156kV	500 at 92kV		-
17	Corona Extinction Voltage (kV)	320	-	-		-
18	Operating mechanism					

	Type:	400 kV	220 kV	132 kV	66 kV	33 kV
I	II	III	IV	V	VI	VII
	a) Isolator	Motor	Motor	Motor	Motor	Motor
	b) Earth switch	Motor	Motor	Motor	Manual	Manual
19	Auxiliary voltage					
	a) Control & Interlock		220V DC 80% to 110%			
	b) Motor voltage		3 Phase 415V AC 50Hz			
	c) Heater, lamp & socket		Single phase 240 V 50HZ			
20	Safe duration of overload					
	150% of rated current		5 minute			
	120% of rated current		30 minute			
21	Minimum creepage distance of insulator (mm)					
22	Mounting structure	Tubular / Lattice	Tubular / Lattice	Tubular / Lattice	Tubular / Lattice	Tubular / Lattice
23	Operating time		Less than 12 secs			
24	Insulator Data					
	a) Bending Strength (kgf)	1000	800	800		600
	b) Height (mm)	3650	2300	1500	As per IS/IEC	508
	c) Bottom PCD (mm)	300	254	184		76
	d) No. of holes & hole dia.	8x18	8x18	4x18		4xM12
	e) Top PCD	127	127	127		76
	f) No. of holes & hole dia.	4xM16	4xM16	4xM16		4xM12
	g) Minimum creepage distance (mm) 31mm/kV	13020	7595	4495	2248	1116
25	Working clearance (live part to ground) (in mm)	8000	5900	4900	As per IS/IEC	4000
26	Phase Spacing (mm.)	6000	4000	3000		1500
27	Minimum clearances (mm.)					
	a) Phase to Phase	4000	2100	1300		320
	b) Phase to earth	3500	2100	1300		320
	c) Sectional clearance	6500	5000	4000		3000

- **SCOPE**

This specification provides for design, manufacturer, testing at manufacturer's Works and delivery, supervision of erection, commissioning (if required) of outdoor station type 400kV/220KV/132KV/ 33KV, Isolator with/ without earth switches, with electrical/**mechanical** interlock, insulators and complete in all respect with bimetallic connectors arcing horns operating mechanism, auxiliary switches, indicating devices, fixing detail etc. as described hereinafter.

10.1 STANDARDS

Disconnecting switches covered by this specification shall conform to latest edition IEC-129/IEC 62271-102 I.S.1813 and IS: 9921, IS-325 and unless specifically stated otherwise in this specification.

10.2 TYPE

The 400,220&132 KV Isolators shall be outdoor type with centre break type/Pantograph type as required [Single(SI)/ Double(DI)] Isolators suitable for electrical as well as manual operation and local/ remote operation; but 33KV Isolators (SI or DI) shall be outdoor type with three phase double break center rotating manual as well as motor operated type with local/remote operation. They shall have crank and reduction gear mechanism.

All Isolators offered shall be suitable for horizontal upright mounting on steel structures. Each pole unit of the multiple Isolators shall be of identical construction and mechanically linked for gang operation.

Each pole of the Isolator shall be provided with two sets of contacts to be operated in series and the moving contact blades shall rotate in horizontal plane.

The design shall be such that the operating mechanism with the linkages shall be suitable for mounting on any of the outer pole ends without much difficulty and with minimum shifting of parts.

Moving contacts of all isolators shall rotate through 90 deg. from their “fully closed position” to “fully open position so that the break is distinct and clearly visible from ground level.

The Isolators offered by the Bidder shall be designed for Normal rating current for Isolator as follows:

400kV	220kV	132kV	66kV	33kV
4000A	3150A	2000/1600/1250A	2000/1250A	2500/1600/1250A

It should suitable for continuous service at the system voltages specified herein. The Isolators shall be suitable to carry the rated current continuously and full short circuit current of 63/50/40/31.5 KA for 400/220/132/33 KV respectively for 3 second at site condition without any appreciable rise in temperature. These shall also be suitable for operation at 110% rated (normal) voltage. The Isolators shall be suitable for Isolating low capacitive / inductive currents of 0.7amp at 0.15 power factor. The isolators shall be so constructed that they don’t open under the influence of short circuit conditions.

The Isolators and earthing switches are required to be used on electrically exposed installation and this should be taken into account while fixing the clearance between phases and between phase and earth. so that de-energized isolator and earth switch also can be manually operated when the parallel

circuit is energized.

10.3 MAIN CONTACTS

All Isolators shall have heavy duty, self-aligning and high-pressure line type **dust-free jaw** contacts made of high conductivity, corrosion resistant, hard-drawn electrolytic copper strips of proper thickness and contact area. Fixed contact should consist of loops of above copper strips suitable for 4000 Amps, 3150 Amps, 2000 Amps, and 1250Amps ratings for 400kV, 220 KV, 132KV and 33KV Isolators respectively. The hard dawn electrolytic copper strips should be silver plated 25micron thickness and fixed contacts should be backed by powerful phosphor bronze/stainless steel springs of suitable numbers. The main contacts should be preferably of tulip type design. However, the thickness and contact area of the contact should conform to the drawing approved during type test. Moving contact with moving arm should be of hard- drawn electrolytic copper of proper thickness and contact area.

These fixed and moving contacts shall be able to carry the rated current continuously and the maximum fault current of 63/50/40/31.5 KA for 400/220/132/33KV respectively for **3 seconds** without any appreciable rise in temperature. The Isolator blades shall retain their form and straightness under all conditions of operation including all mechanical stress arising out of operation as well as under rated short circuit condition.

Fixed guides shall be provided so that even when the blades are out of alignment, closing of the switches, proper seating of the blades in between contacts and adequate pressure to give enough contact surface is ensured. The contact shall be self-cleaning by the wiping action created by the movements of the blades.

The Isolator shall be self-cleaning type so that when isolators remain closed for long periods in a heavily polluted atmosphere, binding does not occur. No undue wear or scuffing shall be evident during the mechanical endurance tests, contacts and springs shall be designed so that adjustment of contact pressure shall not be necessary throughout the life of the isolator. Each contact or part of contacts shall be independently sprung so that full pressure is maintained on all contact at all times.

10.4 ARCING HORN AND GRADING HORN

Suitable arcing horn made of tinned electrolytic copper which are required for guiding contacts shall be provided on the fixed and moving contacts of all Isolators. The contacts shall be of ‘make before and break after” type. Aluminium alloy grading ring are to be provided for 220kV and above voltage level.

10.5 ELECTRICAL INTERLOCK / MECHANICAL INTERLOCK

The disconnecting switches whenever required shall be with an approved type electrical interlock for interlocking with the associated circuit breakers and earth switch.

Electrical interlock shall ensure reliable operation. The design should be such that the electrical circuit for the interlocking mechanism **will remain energised as per operation of the isolator with integrated earth switches.**

10.6. AUXILIARY SWITCHES

All isolators and earthing switches shall be provided with 220VDC auxiliary switches for their remote position indication on the control board and for electrical locking with other equipment. The auxiliary switch shall be provided with a minimum of six auxiliary contacts-10 normally open and 10 normally closed and 10 normally open and 10 normally closed for earth switch. Separate auxiliary switches shall be provided for isolating and earth switches. 6 additional NO and NC contact to be provided as spare in each case.

The auxiliary switches and auxiliary circuits shall have a continuous current carrying capacity of at least 10 Amps. Auxiliary switches shall not be used as limit switches. Details of make, rating and type of limit switch shall be furnished in the offer.

10.7 EARTH SWITCH

Line earth switch shall consist of three earthing blades for Isolator which normally rest against the frame when the connected Isolator is in closed position. The earthing blades for three phases shall be mechanically linked to a coupling shaft which shall be capable of being fitted on either side of the Isolator. The earthing blades shall match and be similar to the main switch blades and shall be provided at the hinge; with suitable flexible conductors with terminal lugs for connecting to the station ground bus. The earthing blades shall be operated by a separate mechanism but shall be mechanically interlocked with the main switch so that the earthing blades can be closed only when the main switches are in open position and vice-versa. The earthing blades shall be gang operated and all the three blades will operate simultaneously.

10.8 OPERATING MACHANISM

The operating mechanism shall be simple and shall ensure quick and effective **10000** mechanical operation. The design shall be such as to enable one man to operate it with nominal effort. The operating mechanism box shall be made out of aluminium extruded (Aluminium alloy) sections of minimum 3.0 mm thickness. The operating mechanism shall be strong rigid and not subject to rebound.

The Isolator blades shall be in positive continuous control throughout the entire cycles of operation. The operating rods and pipes shall be rigid enough to maintain positive control under most adverse conditions and to withstand all torsional and bending stresses arising from operation. Operation of the switches at any speed should not result in improper functioning, in displacement of parts / machines after final adjustment has been made. All holes in cranks, linkages etc. having moving pins shall be fitted accurately so as to prevent slackness and lost motion.

Provision shall be made for padlocking the operating mechanism of disconnecting and earth switches in both open and closed positions.

Bearings shall be ball and roller type shall be protected from weather and dust by means of cover and grease retainers. Bearings pressures shall be kept low to ensure long life and care of operation.

Each power operated isolator shall be motor driven as well as manually operated and shall be complete with local / remote selector switch and open /close push buttons.

Provision shall be made in the control cabinet to disconnect power supply to prevent local / remote power operation. **Limit switches shall be provided with required number of contacts for isolators and earth switches.**

All the terminal blocks to be used in the operating mechanism should of **Ring type** of Poly-amide/Melamine material of make like Elmex/Connectwell.

10.9 DESIGN, MATERIALS AND WORKMANSHIP

The live parts shall be designed to eliminate sharp points, edges and corona producing surfaces. Where this is impracticable, adequate shields to be provided. All ferrous metal parts shall be hot dip galvanized, as per IS 2629.All metal parts shall be of such materials or treated in such a way so as to avoid rust, corrosion and deterioration due to continued exposure to atmosphere and rain. All current carrying parts shall be made from high conductivity electrolytic copper .

Bolts, screws and pins shall be provided with standard locking device viz. Locknuts, spring washers, keys etc. and when used with current carrying parts, they shall be made of copper silicon or other high conductivity and wear resistant alloys.

The **isolators** should not need lubrication of any parts except at very long interval of five year minimum.

10.10 PROTECTIVE COATINGS

All ferrous parts including bolts, nuts and washers of the switches assembly shall be galvanized to withstand at least six one minute dips in copper sulphate solution of requisite strength (Prece tests) except the threaded portions which should withstand four dips.

10.11 INSULATORS

Support insulators for all type of isolators shall be of solid core type. The insulator shall be made of homogeneous and vitreous porcelain of high mechanical and dielectric strength. It shall have sufficient mechanical strength to sustain electrical and mechanical loading on account of wind load, short circuit, **seismic** forces etc. Glazing of the porcelains shall be of uniform dark brown colour with a smooth surface arranged to shed away raise water. The porcelain shall be free from laminations and other flaws or imperfections that might affect the mechanical or dielectric quality. It shall be thoroughly vitrified, tough and impervious to moisture. The porcelain and metal ports shall be assembled in such a manner and with such material that any thermal differential expansion between the metal and porcelain parts throughout the range of temperature specified in this specification shall not loosen the parts or create under internal stresses which may affect the mechanical or electrical strength or rigidity. The assembly shall not have excessive concentration of electrical stresses in any section or across leakage surfaces. The cement used shall not give rise to chemical reaction with metal fittings. The insulator shall be suitable for water washing by rain or artificial means in service condition. Profile of the insulator shall also conform to IEC-815. Caps to be provided on top of the insulator shall be of high-grade cast iron or malleable steel casting. It shall be machine faced and hot dip galvanized. The cap shall have four numbers of tapped holes spaced on a pitch circle diameter of 127mm. The holes shall be suitable for bolts with threads having anti corrosive protection. The effective depth of threads shall not be less than the nominal diameter of the bolt. The cap shall be so designed that it shall be free from visible corona and shall have radio interference level **as specified in table of Clause 10.0** of Casing shall be free from blow holes cracks and such other defects.

10.12 CONTROL CABINET:

The control cabinet of the operating mechanism shall be made out of minimum 3mm thick aluminium alloy sheet. Hinged door shall be provided with pad locking arrangement. Sloping rain hood shall be provided to cover all sides. 15 mm thick neoprene or better type of gaskets shall be provided to ensure degree of protections of at least IP 55 as per IS 2147/IS-3947. The cabinet shall be suitable for mounting on support structure with adjustment for vertical, horizontal and longitudinal alignment. Details of these arrangements shall be furnished along with the offer.

10.13 MOTOR:

Motors rated 0.5 KW and above shall be **provided with** suitable for operation on 3 phase, 415 V, 50 Hz supply. Motors of lower rating shall be single phase type suitable for 240V, 50Hz system. It shall be totally enclosed type if mounted outside the control cabinet. The motor shall withstand without damage stalled torque for at least 3 times the time lag of the tripping device. The motor shall, in all other respects, conform to the requirement of I.S. 325**. Suitable relay/device shall be provided to prevent over loading of the motor. Single phase preventer (for 3 phase meter) shall be provided to operate on open circuiting of any phase and shall trip off the motor. Complete details of the devices shall be furnished in the offer.**

10.14 GEAR:

The dis-connector / isolator may be required to operate occasionally, with considerably long idle intervals. Special care shall be taken for selection of material for gear and lubrication of gears to meet this requirement. The gear shall be made out of aluminium bronze or any other better material lubricated for life with graphite or better-quality non-drawing and non-hardening type grease. Wherever necessary automatic relieving mechanism shall be provided.

10.15 SPACE HEATERS:

Space heaters suitable for 1 phase 240V AC supply shall be provided for each motor operated operating mechanism to prevent condensation and shall be operated by MCB.

10.16 TERMINAL BLOCK AND WIRINGS

Each operating mechanism shall be provided with 1100V grade **ring** type terminal block. All auxiliary switches, **spare contact of the contactors**, interlocks and other terminals shall be wired up to terminal block. The terminal block shall have at least 20% extra terminals. All wiring shall be carried out with 1.1KV grade **PVC** insulated 2.5 sq.mm. copper wires.

10.17 INTERIOR ILLUMINATION:

A holder suitable for a 240 V lamp shall be provided in each of the motor operated mechanism of three poles & shall be door operated type.

10.18 CONTROL AND AUXILIARY SUPPLY:

A 3-phase switch with MCB for phases and link for neutral, shall be provided for power supply and a 2 pole MCB shall be provided for control supply.

10.19 POSITION INDICATOR:

A position indicator to show the isolator is in ON or OFF position to be provided.

10.20 NAME PLATE:

Isolator, earthing switches and their operating devices shall be provided with name plate. The name plate shall be weatherproof and corrosion proof. It shall be mounted in such a position that it shall be visible in the position of normal service and installation. It shall carry the following informations duly engraved or punched on it.

A. Isolator Base

Name: AEGCL

Name of manufacturer –

Order No. –

Type Designation –

Manufacturers serial No. –

Rated voltage –

Rated normal current –

Rated short time current (rms) and duration –

Rated short time peak current (KAP)

Weight-

Manufacturing Statndard-

B. **Earthing Switch**

Name: AEGCL

Name of manufacturer –

Order No. –

Type Designation –

Manufacturers serial No. –

Rated voltage –

Rated normal current –

Rated short time current (rms) and duration

Rated short time peak current (KAP)

Weight

C. **Operating Device**

Name – AEGCL

Name of manufacturer –

Order No.

Type Designation –

Reduction gear ratio –

AC motor

i) Rated auxiliary voltage

ii) Starting current

iii) Designation of AC motor as per IS 4722/325

iv) Starting torque at 80% of supply voltage

v) Over travel in degrees after cutting off supply

Total operating time in seconds

i) Close operation – Electrical

ii) Open operation – electrical

iii) Open operation – manual

10.21 PAINTING GALVANIZING AND CLIMATE PROOFING:

At interiors and exteriors of enclosures, cabinets and other metal parts (other than made up of aluminium) shall be thoroughly cleaned to remove all rust, scales, corrosion, grease and other adhering foreign matter and the surfaces treated by phosphating (e.g. seven tank phosphating sequence). After such preparation of surfaces, two coats of zinc oxide primer shall be given by suitable stoving and air drying before final painting **with epoxy paint.** Colour of the final paints shall be of shade no. 697 of IS:5. The finally painted cubicle shall present aesthetically pleasing appearance free from any dent or uneven surface.

Paint inside the metallic housing shall be of anti-condensation type and the paint on outside surfaces shall be suitable for outdoor installation.

All components shall be given adequate treatment of climate proofing as per IS:3202 so as to withstand corrosive and severe service conditions.

All metal parts not suitable for painting such as structural steel, pipes, rods, levers, linkages, nuts and bolts used in other than current path etc. shall be hot dip galvanized as per IS – 2629. Galvanization test will be carried out during routine test.

Complete details of painting, galvanizing and climate proofing of the equipment shall be furnished in the offer.

10.22 TESTS:

Type Tests:

Isolators offered, shall be fully type tested as per the relevant standards. The Bidder shall furnish Three sets of the following valid type test reports for their different type of offered Isolators along with the offer. The AEGCL reserves the right to demand repetition of some or all the type tests in the presence of AEGCL's representative. For this purpose, the Bidder may quote unit rates for carrying out each type test and this will be taken during bid price evaluation, if required.

a) short time withstand & peak withstand current test for Isolator & Earth Switch.

b) power frequency (Dry & Wet), Lightening Impulse dry withstand Test

c) Mechanical endurance Test

d) IP-55 test

e) Seismic test

f) Temperature Rise test

During type tests the isolator shall be mounted on its own support structure or equivalent support structure and installed with its own operating mechanism to make the type tests representative. Drawing of equivalent support structure and mounting arrangements shall be furnished for Purchaser's approval before conducting the type tests.

The type tests shall be conducted on the isolator along with approved insulators and terminal connectors. Mechanical endurance test shall be conducted on the main switch as well as earth switch of one isolator of each type.

Acceptance and Routine Test:

All acceptance and routine test as stipulated in the relevant standards shall be carried out by the supplier in presence of Purchaser's representative.

Mechanical operation test (routine test) shall be conducted on isolator (main switch and earth switch) at the supplier's works as well as purchaser's substation site.

Immediately after finalization of the programme of type / acceptance, routine testing the supplier shall give sufficient advance intimation (clear 20 days advance intimation), along with shop routine test certificates, valid calibration reports from Govt. approved **(NABL)** test house for the equipment, instruments to be used during testing for scrutiny by the AEGCL to enable him to depute his representative for witnessing the tests. If there will be any discrepancies in the shop routine test certificates and calibration reports furnished by the firm then after settlement of the discrepancies only, purchaser's representative will be deputed for witnessing the tests. Special tests proposed to be conducted (if decided to conduct) as type test on isolators, are given at Annexure- II. Thesespecial type test charges shall be quoted along with all other type tests as per relevant IEC standard and these charges shall be included in the total bid price

Test certificates of various items including but not limited to the following shall be furnished at the time of routine tests.

a) Chemical analysis of copper along with a copy of excise certificate indicating genuine source of procurement of electrolytic grade copper.

b) Bearings

c) Fasteners

d) Universal / swivel joint coupling

e) Insulators

f) Motor

g) Gears

h) Auxillary switch

i) Limit switch

j) Timer

k) Overload / single phase preventer relay

l) Interlocking devices

m) Terminal block

n) Any other item

10.23 INSPECTION:

i) The Purchaser shall have access at all times to the works and all other places of manufacture, where the disconnectors, earth switches and associated equipment are being manufactured and the supplier shall provide all facilities for unrestricted inspection of the works raw materials manufacture of all the accessories and for conducting necessary tests as detailed herein.

ii) The supplier shall keep the purchaser informed in advance of the time of starting of the progress of manufacture of equipment in its various stages so that arrangements could be made for inspection.

iii) No material shall be dispatched from its point of manufacture unless the material has been satisfactorily inspected and tested.

iv) The acceptance of any quantity of the equipment shall in no way relieve the supplier of his responsibility for meeting all the requirements of this specification and shall not prevent subsequent rejection if such equipment is later found to be defective.

10.24 QUALITY ASSURANCE PLAN:

The Bidder shall invariably furnish following information along with his offer, failing which his offer shall be liable for rejection.

(i) Names of sub suppliers for raw materials, list of standards according to which the raw materials are tested, list of tests normally carried out on raw materials in presence of Supplier’s representative, copies of test certificate

(ii) Information and copies of test certificates as in (i) and (ii) above in respect of bought out accessories.

(iii) List of manufacturing facilities available

(iv) Level of automation achieved and lists of areas where manual processing still exists.

(v) List of areas in manufacturing process, where stage inspections are normally carried out for quality control and details of such tests and inspections.

(vi) List of testing equipment with calibration certificates from Govt. approved**(NABL)** test house available with supplier for final testing equipment and test plant limitation if any, vis-à-vis the type, special acceptance and routine test specified in the relevant standards. These limitations shall be very clearly brought out in the specified test requirements.

(vii) QAP shall include acceptance criteria mentioning clause no. of applicable standard against each parameter.

The supplier shall within 30 days of placement of order, submit following information to the purchaser.

i) List of raw material as well as bought out accessories and the names of sub-suppliers selected from the lists furnished along with offer.

ii) Type test certificates of the raw material and both bought out accessories.

iii) Quality Assurance Plan (QAP) withhold points for purchaser’s inspection.

The supplier shall submit the routine test certificates of bought out accessories and raw material viz. Copper, aluminum conductors, lubricating material, gear material etc. at the time of routine testing of the fully assembled isolator.

10.25 DOCUMENTATION:

All drawings shall conform to relevant international standards organization (ISO).. All dimensions and data shall be in S.I. Units.

List of Drawings and Documents

The Bidder shall furnish **four** sets of following drawings / documents along with his offer.

a) General outline and assembly drawings of the dis-connector operating mechanism, structure, insulator and terminal connector.

b) Sectional views and descriptive details of items such as moving blades, contacts, arms contact pressure, contact support bearing housing of bearings, balancing of heights, phase coupling pipes, base plate, operating shaft, guides, swivel joint operating mechanism and its components etc.

c) Loading diagram

d) Drawings with structure for the purpose of type tests.

e) Name plate.

f) Schematic drawing.

g) Type test reports.

h) Test reports, literature, pamphlets of the bought-out items and raw material.

i) Deviation sheet/compliance sheet if applicable

Six sets of the type test report, duly approved by the Purchaser shall be submitted by the supplier for distribution, before commencement of supply Adequate copies of acceptance and routine test certificates, duly approved by the Purchaser shall accompany the dispatched consignment.

The manufacturing of the equipment shall be strictly in accordance with the approved drawings and no deviation shall be permitted without the written approval of the purchaser. All manufacturing and fabrication work in connection with the equipment prior to the approval of the drawing shall be at the supplier risk.

The supplier shall within 2 weeks of placement of order submit four sets of final versions of all the above said drawings for AEGCL's approval. The purchaser shall communicate his comments / approval on the drawings to the supplier. The supplier shall, if necessary, modify the drawings and resubmit four copies of the modified drawings for AEGCL's approval within two weeks from the date of comments.

10.26 INSTRUCTION MANUALS:

Fifteen copies of the erection, operation and maintenance manuals in English to be supplied for each type of disconnector one month prior to dispatch of the equipment. The manual shall be bound volumes and shall contain all drawings and information required for erection, operation and maintenance of the disconnector including but not limited to the following particulars.

(a) Marked erection prints identifying the component parts of the disconnector as shipped with assembly drawings.

(b) Detailed dimensions and description of all auxiliaries.

(c) Detailed views of the insulator stacks, metallics, operating mechanism, structure, interlocks, spare parts etc.

10.27 PACKING AND FORWARDING:

The equipment shall be packed in crates suitable for vertical / horizontal transport, as the case may be and suitable to withstand handling during transport and outdoor storage during transit. The supplier shall be responsible for any damage to the equipment during transit, due to improper and inadequate packing. The easily damageable material shall be carefully packed and marked with the appropriate caution symbols.

Wherever necessary, proper arrangement for lifting, such as lifting hooks etc. shall be provided. Any material found short inside the packing cases shall be supplied by supplier without any extra cost.

Each consignment shall be accompanied by a detailed packing list containing the following information:

(a) Name of the consignee.

(b) Details of consignment.

(c) Destination.

(d) Total weight of consignment.

(e) Handling and unpacking instructions.

(f) Bill of material indicating contents of each package.

The supplier shall ensure that the bill of material is approved by the purchaser before dispatch.

10.28 SUPERVISION OF ERECTION TESTING AND COMMISSIONING (ET&C):

Purchaser proposes to utilize the services of the supplier for supervision of testing and commissioning of the equipment being supplied by him, if it is required. For this purpose, the supplier should make available the services of trained personnel (Engineers) who shall correct in the field, any errors or omissions in order to make the equipment and material properly perform in accordance with the intent of this specification. The Engineer shall also instruct the plant operators in the operation and maintenance of the commissioned equipment. The supplier shall be responsible for any damage to the equipment on commissioning the same, if such damage results for the faulty or improper ET&C. Purchaser shall provide adequate number of skilled / semi-skilled workers as well as ordinary tools and equipment and cranes required for equipment erection, at his own expenses. Apart from the above, the Purchaser shall not be responsible for providing any other facilities to the supplier. Special tools if required for erection and commissioning shall be arranged by the supplier at his cost and on commissioning these shall be supplied to the purchaser free of cost for future use.

APPENDIX – I

(Isolators)

LIST OF SPECIAL TESTS TO BE CARRIED OUT IF DECIDED BY THE PURCHASER

Sl. No.	Name of the Test	Standard to which it conforms.
1.	Test for visible Corona and Radio interference voltage (RIV) on disconnectors and terminal	NEMA Pub No. 107-1964 ISRI Pub No. 1-1972
2.	Tests on insulators	IS-2544 IEC. 168
3.	Tests on terminal connectors	IS:5561
4.	Tests on galvanized components	IS:2633
5.	Stalled torque test on motor operating mechanism	At 110% of supply voltage

CHAPTER 11: 3-PHASE 1 MVA STATION SERVICE TRANSFORMER [33 KV/433V] (OUTDOOR TYPE)

11.1. SCOPE:

i) This specification covers design, engineering, manufacture, assembly, stage testing, inspection and testing before supply and delivery at site of oil immersed, naturally cooled 3-phase 33 kV/433V station service transformers for outdoor use.

ii) The equipment shall conform in all respects to high standards of engineering, design and workmanship and shall be capable of performing in continuous commercial operation, in a manner acceptable to the purchaser, who will interpret the meanings of drawings and specification and shall have the power to reject any work or material which, in his judgment is not in accordance therewith. The offered equipment shall be complete with all components necessary for their effective and trouble-free operation. Such components shall be deemed to be within the scope of bidder's supply irrespective of whether those are specifically brought out in this specification and / or the commercial order or not.

iii) The transformer and accessories shall be designed to facilitate operation, inspection, maintenance and repairs. The design shall incorporate every precaution and provision for the safety of equipment as well as staff engaged in operation and maintenance of equipment.

iv) All outdoor apparatus, including bushing insulators with their mountings, shall be designed so as to avoid any accumulation of water.

11.2 STANDARD RATINGS:

The standard ratings shall be 1000 kVA (1 MVA) and 250kVA for 33 kV Station service transformers under current scope.

STANDARDS:

11.2.1 The major materials used in the transformer shall conform in all respects to the relevant/specified Indian Standards and international Standards with latest amendments thereof as on bid opening date, unless otherwise specified herein. Some of the applicable Indian Standards are listed as hereunder:

11.2.2

Indian Standards	Title	International Standards
IS -2026	Specification for Power Transformers	IEC 76
IS 1180 (Part-I): 2014	Outdoor Type Oil Immersed Distribution Transformers upto and including 2500kVA, 33kV- Specification	
IS 12444	Specification for Copper wire rod	ASTM B-49
IS-335	Specification for Transformer/Mineral Oil	IEC Pub 296
IS-5	Specification for colors for ready mixed paints	
IS -104	Ready mixed paint, brushing zinc chromate, priming	
IS-2099	Specification for high voltage porcelain bushing	
IS-649	Testing for steel sheets and strips and magnetic circuits	
IS- 3024	Cold rolled grain oriented electrical sheets and strips	
IS – 4257	Dimensions for clamping arrangements for bushings	
IS – 7421	Specification for Low Voltage bushings	
IS – 3347	Specification for Outdoor Bushings	DIN 42531 to 33
IS – 5484	Specification for Al Wire rods	ASTM B - 233

IS – 9335	Specification for Insulating Kraft Paper	IEC 554
IS – 1576	Specification for Insulating Press Board	IEC 641
IS – 6600	Guide for loading of oil Immersed Transformers	IEC 76
IS – 2362	Determination of water content in oil for porcelain bushing of transformer	
IS – 6162	Paper covered Aluminium conductor	
IS – 6160	Rectangular Electrical conductor for electrical machines	
IS – 5561	Electrical power connector	
IS – 6103	Testing of specific resistance of electrical insulating liquids	
IS – 6262	Method of test for power factor and dielectric constant of electrical insulating liquids	
IS – 6792	Determination of electrical strength of insulating oil	
IS – 10028	Installation and maintenance of transformers.	
CBIP Manual 295	CBIP manual on transformer	

11.3 SERVICE CONDITIONS:

The Station Service Transformers to be supplied against this Specification shall be suitable for satisfactory continuous operation under the following climatic conditions as per IS 2026 (Part - I) and General Technical Requirements (GTR)

Note

1. The climatic conditions specified above are indicative and can be changed by the user as per requirements.

2. The equipment shall generally be for use in moderately hot and humid tropical climate, conducive to rust and fungus growth unless otherwise specified.

11.4 PRINCIPAL PARAMETERS:

11.4.1 The transformers shall be suitable for outdoor installation with three phase, 50 Hz, 33 kV system in which the neutral is effectively earthed and they should be suitable for service with fluctuations in supply voltage up to plus 12.5% to minus 12.5%.

(i) The transformers shall conform to the following specific parameters:

Sl.No.	Item	33 kV Distribution Transformers
1	System voltage (Max.)	36 kV
2	Rated Voltage (HV)	33 kV
3	Rated Voltage (LV)	433 V
4	Frequency	50 Hz +/- 5%
5	No. of Phases	Three
6	Connection HV	Delta
7	Connection LV	Star (Neutral brought out)

8	Vector group	Dyn-11
9	Type of cooling	ONAN

Audible sound levels (decibels) at rated voltage and frequency for liquid immersed distribution transformers shall be as below (NEMA Standards):

kVA rating	Audible sound levels (decibels)
0-50	48
51-100	51
101-300	55
301-500	56
750	57
1000	58
1500	60
2000	61
2500	62

11.5 TECHNICAL REQUIREMENTS:

11.5.1 CORE MATERIAL

a) The core shall be stack / wound type of high-grade Cold Rolled Grain Oriented or Amorphous Core annealed steel lamination having low loss and good grain properties, coated with hot oil proof insulation, bolted together and to the frames firmly to prevent vibration or noise. The core shall be stress relieved by annealing under inert atmosphere if required. The complete design of core must ensure permanency of the core loss with continuous working of the transformers. The value of the maximum flux density allowed in the design and grade of lamination used shall be clearly stated in the offer.

b) The bidder should offer the core for inspection and approval by the purchaser during manufacturing stage. CRGO steel for core shall be purchased only from reputed vendors.

c) The transformers core shall be suitable for over fluxing (due to combined effect of voltage and frequency) up to 12.5% without injurious heating at full load conditions and shall not get saturated. The bidder shall furnish necessary design data in support of this situation.

d) No-load current up to 200kVA shall not exceed 3% of full load current and will be measured by energizing the transformer at rated voltage and frequency. Increase of 12.5% of rated voltage shall not increase the no-load current by 6% of full load current or No-load current above 200kVA and upto 2500kVA shall not exceed 2% of full load current and will be measured by energising the transformer at rated voltage and frequency. Increase of 12.5% of rated voltage shall not increase the no-load current by 5% of full load current.

11.6 WINDINGS:

11.6.1 Material:

11.6.1.1 HV and LV windings shall be wound from Super Enamel covered /Double Paper covered Aluminum / Electrolytic Copper conductor.

11.6.1.2 LV winding shall be such that neutral formation will be at top.

11.6.1.3 The winding construction of single HV coil wound over LV coil is preferable.

11.6.1.4 Inter layer insulation shall be Nomex /Epoxy dotted Kraft Paper.

11.6.1.5 Proper bonding of inter layer insulation with the conductor shall be ensured. Test for bonding strength shall be conducted.

11.6.1.6 Dimensions of winding coils are very critical. Dimensional tolerances for winding coils shall be within limits as specified in Guaranteed Technical Particulars.

11.6.1.7 The core/coil assembly shall be securely held in position to avoid any movement under short circuit conditions.

11.6.1.8 Joints in the winding shall be avoided. However, if jointing is necessary the joints shall be properly brazed and the resistance of the joints shall be less than that of parent conductor. In case of foil windings, welding of leads to foil can be done within the winding.

11.7 TAPPING RANGES AND METHODS:

11.7.1 For ratings above 100 kVA and up to 500 kVA, tappings shall be provided, **if required by the purchaser**, on the higher voltage winding for variation of HV voltage within range of (+) 5.0 % to (-) 10% in steps of 2.5%.

11.7.2 For ratings greater than 500 kVA, tapping shall be provided on the higher voltage winding for variation of HV voltage within range of (+) 2.5% to (-) 5.0 % in steps of 2.5%.

11.7.3 Tap changing shall be carried out by means of an externally operated self-position switch and when the transformer is in de-energised condition. Switch position No.1 shall correspond to the maximum plus tapping. Each tap change shall result in variation of 2.5% in voltage. Arrangement for pad locking shall be provided. Suitable aluminum anodized plate shall be fixed for tap changing switch to know the position number of tap.

11.8 OIL:

11.8.1 The insulating oil shall comply with the requirements of IS 335. Use of recycled oil is not acceptable. The specific resistance of the oil shall not be less than 35 X10^{12} ohm-cm at 27^{o}C when tested as per IS 6103.

11.8.2 Oil shall be filtered and tested for break down voltage (BDV) and moisture content before filling.

11.8.3 The oil shall be filled under vacuum.

11.8.4 The design and all materials and processes used in the manufacture of the transformer, shall be such as to reduce to a minimum the risk of the development of acidity in the oil.

11.9 INSULATION LEVELS:

Sl. No.	Voltage (kV)	Impulse Voltage (kV Peak)	Power Frequency Voltage(kV)
1	0.433	-	3
2	33	170	70

11.10 LOSSES:

11.10.1 The transformer of HV voltage up to 11kV, the total losses (no-load + load losses at 75 °C) at 50% of rated load and total losses at 100% of rated load shall not exceed the maximum total loss values given in Table-3 up to 200kVA & Table-6 for ratings above 200kVA of IS 1180(Part-1):2014.

11.10.2 The maximum allowable losses at rated voltage and rated frequency permitted at 75°C for 33/0.433 kV transformers can be chosen by the utility as per **Table-3 up to 200kVA** and **Table-6 for ratings above 200kVA** as per **Energy Efficiency Level-3 specified in IS 1180 (Part-1): 2014** for all kVA ratings of distribution transformers.

11.10.3 The above losses are maximum allowable and there would not be any positive tolerance. Bids with higher losses than the above specified values would be treated as non-responsive. However, the manufacturer can offer losses less than above stated values. The utility can evaluate offers with losses lower than the maximum allowable losses on total owning cost basis in accordance with methodology given in CBIP Manual (Publication No. 317).

11.11 TOLERANCES:

No positive tolerance shall be allowed on the maximum losses displayed on the label for both 50% and 100% loading values.

11.12 PERCENTAGE IMPEDANCE:

The percentage impedance of transformers at 75 0C for different ratings upto 200 kVA shall be as per Table 3 and for ratings beyond 200 kVA shall be as per Table 6 of IS 1180(Part-1):2014/CBIP-295.

11.13 Temperature rise: The temperature rise over ambient shall not exceed the limits given below:

11.13.1 Top oil temperature rise measured by thermometer :35°C

11.13.2 Winding temperature rise measured by resistance method :40°C

11.13.3 The transformer shall be capable of giving continuous rated output without exceeding the specified temperature rise. Bidder shall submit the calculation sheet in this regard.

11.14 **PENALTY** FOR NON-PERFORMANCE:

11.14.1 During testing at supplier's works if it is found that the actual measured losses are more than the values quoted by the bidder, the purchaser shall reject the transformer and he shall also have the right to reject the complete lot.

11.14.2 Purchaser shall reject the entire lot during the test at supplier's works, if the temperature rise exceeds the specified values.

11.14.3 Purchaser shall reject any transformer during the test at supplier's works, if the impedance values differ from the guaranteed values including tolerance.

11.14.4 Loss capitalization shall be as per CBIP-295.

11.15 INSULATION MATERIAL:

11.15.1 Electrical grade insulation epoxy dotted Kraft Paper/Nomex and pressboard of standard make or any other superior material subject to approval of the purchaser shall be used.

11.15.2 All spacers, axial wedges / runners used in windings shall be made of pre-compressed Pressboard-solid, conforming to type B 3.1 of IEC 641-3-2. In case of cross-over coil winding of HV all spacers shall be properly sheared and dovetail punched to ensure proper locking. All axial wedges / runners shall be properly milled to dovetail shape so that they pass through the designed spacers freely. Insulation shearing, cutting, milling and punching operations shall be carried out in such a way, that there should not be any burr and dimensional variations.

11.16 TANK:

- Transformer tank construction shall conform in all respect to clause 15 of IS 1180(Part-1):2014.
- The internal clearance of tank shall be such, that it shall facilitate easy lifting of core with coils from the tank without dismantling LV bushings.
- All joints of tank and fittings shall be oil tight and no bulging should occur during service.
- Inside of tank shall be painted with varnish/hot oil resistant paint.
- The top cover of the tank shall be slightly sloping to drain rain water.
- The tank plate and the lifting lugs shall be of such strength that the complete transformer filled with oil may be lifted by means of lifting shackle.
- Manufacturer should carry out all welding operations as per the relevant ASME standards and submit a copy of the welding procedure and welder performance qualification certificates to the customer.

11.17 PLAIN TANK:

11.17.1 The transformer tank shall be of **rigid design and** robust construction rectangular/octagonal/round/elliptical in shape and shall be built up of electrically tested welded mild steel plates of thickness of 3.15 mm for the bottom and top and not less than 2.5 mm for the sides for transformers upto and including 25 kVA, 5.0 mm and 3.15 mm respectively for transformers up to and including 100 kVA and 6 mm and 4 mm respectively above 100 kVA. Tolerances as per IS1852 shall beapplicable.

11.17.2 In case of rectangular tanks above 100 kVA the corners shall be fully welded at the corners from inside and outside of the tank to withstand a pressure of 0.8 kg/cm^2 for 30 minutes. In case of transformers of 100 kVA and below, there shall be no joints at corners and there shall not be more than 2 joints in total.

11.17.3 Under operating conditions, the pressure generated inside the tank should not exceed 0.4 kg/ sq. cm positive or negative. There must be sufficient space from the core to the top cover to take care of oil expansion. The space above oil level in the tank shall be filled with dry air or nitrogen conforming to commercial grade of IS 1747.

11.17.4 The tank shall be reinforced by welded flats on all the outside walls on the edge of the tank.

11.17.5 Permanent deflection: The permanent deflection, when the tank without oil is subjected to a vacuum of 525 mm of mercury for rectangular tank and 760 mm of mercury for round tank, shall not be more than the values as given below:

(All figures are in mm)

Horizontal length of flat plate	Permanent deflection
Up to and including 750	5.0
751 to 1250	6.5
1251 to 1750	8.0
1751 to 2000	9.0

11.17.6 The tank shall further be capable of withstanding a pressure of 0.8kg/sq.cm and a vacuum of 0.7 kg/sq.cm (g) without any deformation.

11.17.7 The radiators can be tube type or fin type or pressed steel type to achieve the desired cooling to limit the specified temperature rise.

11.18 CORRUGATED TANK:

11.18.1 The bidder may offer corrugated tanks for transformers of all ratings.

11.18.2 The transformer tank shall be of robust construction corrugated in shape and shall be built up of tested sheets.

11.18.3 Corrugation panel shall be used for cooling. The transformer shall be capable of giving continuous rated output without exceeding the specified temperature rise. Bidder shall submit the calculation sheet in this regard.

11.18.4 Tanks with corrugations shall be tested for leakage test at a pressure of 0.25kg/ sq cm measured at the top of the tank.

11.18.5 The transformers with corrugation should be provided with a pallet for transportation, the dimensions of which should be more than the length and width of the transformer tank with corrugations.

11.19 CONSERVATOR:

11.19.1 Transformers **shall be of** plain tank construction, the provision of conservator is mandatory. For corrugated tank and sealed type transformers with or without inert gas cushion, conservator is not required.

11.19.2 When a conservator is provided, oil gauge and the plain or dehydrating breathing device shall be fitted to the conservator which shall also be provided with a drain plug and a filling hole [32 mm (1¼”)] normal size thread with cover. In addition, the cover of the main tank shall be provided with an air release plug.

11.19.3 The dehydrating agent shall be silica gel. The moisture absorption shall be indicated by a change in the colour of the silica gel **crystals (Orange Color)** which should be easily visible from a distance. Volume of breather shall be suitable for 500g of silica gel conforming to IS 3401 for transformers upto 200kVA and 1 kg for transformers above 200 kVA.

11.19.4 The capacity of a conservator tank shall be designed keeping in view the total quantity of oil and its contraction and expansion due to temperature variations. The total volume of conservator shall be such as to contain10% quantity of the oil. Normally 3% quantity the oil shall be contained in the conservator.

11.19.5 The cover of main tank shall be provided with an air release plug to enable air trapped within to be released, unless the conservator is so located as to eliminate the possibility of air being trapped within the main tank.

11.19.6 The inside diameter of the pipe connecting the conservator to the main tank should be within 20 to 50 mm and it should be projected into the conservator so that its end is approximately 20 mm above the bottom of the conservator so as to create a sump for collection of impurities. The minimum oil level (corresponding to -5 0C) should be above the sump level.

11.20 SURFACE PREPARATION AND PAINTING:

11.20.1 GENERAL

11.20.1.1All paints, when applied in a normal full coat, shall be free from runs, sags, wrinkles, patchiness, brush marks or other defects.

11.20.1.2All primers shall be well marked into the surface, particularly in areas where painting is evident and the first priming coat shall be applied as soon as possible after cleaning. The paint shall be applied by airless spray according to manufacturer's recommendations. However, where ever airless spray is not possible, conventional spray be used with prior approval of purchaser.

11.20.2 CLEANING AND SURFACE PREPARATION:

11.20.2.1 After all machining, forming and welding has been completed, all steel work surfaces shall be thoroughly cleaned of rust, scale, welding slag or spatter and other contamination prior to any painting.

11.20.3 Steel surfaces shall be prepared by shot blast cleaning (IS9954) to grade Sq. 2.5 of ISO 8501-1 or chemical cleaning including phosphating of the appropriate quality (IS 3618).

11.20.4 Chipping, scraping and steel wire brushing using manual or power-driven tools cannot remove firmly adherent mill-scale. These methods shall only be used where blast cleaning is impractical. Manufacturer to clearly explain such areas in his technical offer.

11.21 PROTECTIVE COATING:

11.21.1 As soon as all items have been cleaned and within four hours of the subsequent drying, they shall be given suitable anti-corrosion protection.

11.22 PAINT MATERIAL:

11.22.1 Following are the types of paint which may be suitably used for the items to be painted at shop and supply of matching paint to site:

Heat resistant paint (Hot oil proof) for inside surface

11.22.2 For external surfaces one coat of thermo setting powder paint or one coat of epoxy primer followed by two coats of synthetic enamel/polyurethene base paint. These paints can be either air drying or stoving.

11.22.3 For highly polluted areas, chemical atmosphere or for places very near to the sea coast, paint as above with one coat of high build Micaceous iron oxide (MIO) as an intermediate coat may be used.

11.23 PAINTING PROCEDURE:

11.23.1 All prepared steel surfaces should be primed before visible re-rusting occurs or within 4 hours, whichever is sooner. Chemical treated steel surfaces shall be primed as soon as the surface is dry and while the surface is still warm.

11.23.2 Where the quality of film is impaired by excess film thickness (wrinkling, mud cracking or general softness) the supplier shall remove the unsatisfactory paint coating and apply another coating. As a general rule, dry film thickness should not exceed the specified minimum dry film thickens by more than 25%.

11.24 DRY FILM THICKNESS:

11.24.1 To the maximum extent practicable the coats shall be applied as a continuous film of uniform thickness and free of pores. Overspray, skips, runs, sags and drips should be avoided. The different coats may or may not be of the same colour.

11.24. 2 Each coat of paint shall be allowed to harden before the next is applied as per manufacturer's recommendation.

11.24.3Particular attention must be paid to full film thickness at the edges.

11.24.4 The requirements for the dry film thickness (DFT) of paint and the materials to be used shall be as given below:

Sl. No.	Paint type	Area to be painted	No. of coats	Total dry film thickness (min.) (microns)
1.	Thermo setting powder paint	inside outside	01 01	30 60
2.	**Liquid paint** a) Epoxy (primer) b) P.U. Paint (Finish coat) c) Hot oil paint/ Varnish	outside outside inside	01 02 01	30 25 each 35/10

11.25 TESTS FOR PAINTED SURFACE:

11.25.1 The painted surface shall be tested for paint thickness.

11.25.2 The painted surface shall pass the cross hatch adhesion test and impact test as acceptance tests and Salt spray test and Hardness test as type test as per the relevant ASTM standards.

Note: Supplier shall guarantee the painting performance requirement for a period of not less than 5 years.

11.26 BUSHINGS:

11.26.1 The bushings shall conform to the relevant standards specified and shall be of outdoor type. The bushing rods and nuts shall be made of brass material 12 mm diameter for both HT and LT bushings. The bushings shall be fixed to the transformers on side with straight pockets and in the same plane or the top cover for transformers above 100 kVA. For transformers of 100 kVA and below the bushing can be mounted on pipes. The tests as per latest IS 2099 and IS 7421 shall be conducted on the transformer bushings.

11.26.2 For 33kV ,52kV class outdoor bushings shall be used for transformers of ratings 500kVA and above. **And for LT bushing of 0.433 kV, 1.1 kV class bushings shall be used..**

11.26.3 Bushing can be of porcelain. Polymer insulator bushings conforming with relevant IEC can also be used.

11.26.4 Bushings of plain shades as per IS 3347 shall be mounted on the side of the Tank and not on top cover.

11.26.5 Dimensions of the bushings of the voltage class shall conform to the Standards specified and dimension of clamping arrangement shall be as per IS 4257

11.26.6 Minimum external phase to phase and phase to earth clearances of bushing terminals shall be as follows:

Voltage	**Clearance**	
	Phase to phase	**Phase to earth**
33 kV	350mm	320mm
LV	75mm	40mm

The clearances in case of cable box shall be as below:

Voltage	**Clearance**	
	Phase to phase	**Phase to earth**
33 kV	350mm	220mm
LV	25mm	20mm

11.26.7 Arcing horns shall be provided on HV bushings.

11.26.8 Brazing of all inter connections, jumpers from winding to bushing shall have cross section larger than the winding conductor. All the Brazes shall be qualified as per ASME, section – IX.

11.26.9 The bushings shall be of reputed make supplied by those manufacturers who are having manufacturing and testing facilities for insulators.

11.26.10 **LT terminal bushings shall be dry type in air to be housed in cable box**.

11.27 TERMINAL CONNECTORS:

11.28.1 The LV and HV bushing stems shall be provided with suitable terminal connectors as per IS 5082 so as to connect the jumper without disturbing the bushing stem. Connectors shall be with eye bolts so as to receive conductor for HV. Terminal connectors shall be type tested as per IS 5561.

11.28 LIGHTNING ARRESTORS:

11.28.1 9 kV, 5 kA metal oxide lightning arrestors of reputed make conforming to IS 3070 Part-III, one number per phase shall be provided. (To be mounted on pole or to be fitted under the HV bushing with GI earth strip 25x4 mm connected to the body of the transformer with necessary clamping arrangement as per requirement of purchaser.) Lightening arrestors with polymer insulators in conformance with relevant IEC can also be used.

11.29 CABLE BOXES:

11.29.1 LV terminations are to be made through cables the transformer shall be fitted with suitable cable box on **LV side to terminate minimum one 3 core copper (Cu) conductor cable (Size as per requirement).**

The bidder shall ensure the arrangement of LV Cable box so as to prevent the ingress of moisture into the box due to rain water directly falling on the box. The cable box on LV side shall be of the split type with faces plain and machined and fitted with Neo-k-Tex or similar quality gasket and complete with brass wiping gland to be mounted on separate split type gland plate with nut-bolt arrangement and MS earthing clamp. The bushings of the cable box shall be fitted with nuts and stem to take the cable cores without bending them. The stem shall be of copper with copper nuts. The cross section of the connecting rods shall be stated and shall be adequate for carrying the rated currents. On the LV side the terminal rod shall have a diameter of not less than 12 mm. The material of connecting rod shall be copper**. LV** Cable support clamp should be provided to avoid tension due to cable weight.

11.29.2 The transformer shall be fitted with suitable LV cable box having non-magnetic material gland plate with appropriately sized single compression brass glands on LV side to terminate 1.1 kV/single core XLPE armoured copper **(Cu)** cable (Size as per requirement)

11.30 TERMINAL MARKINGS:

High voltage phase windings shall be marked both in the terminal boards inside the tank and on the outside with capital letter 1U, 1V, 1W and low voltage winding for the same phase marked by corresponding small letter 2u, 2v, 2w. The neutral point terminal shall be indicated by the letter 2n. Neutral terminal is to be brought out and connected to local grounding terminal by an
earthing strip **mounted on insulators.**

11.31 CURRENT TRANSFORMERS:

11.31.1 The following standard fittings shall be provided:

i. Rating and terminal marking plates, non-detachable.

ii. Earthing terminals with lugs - 2 Nos.

iii. Lifting lugs for main tank and top cover

iv. Terminal connectors on the HV/LV bushings (For bare terminations only).

v. Thermometer pocket with cap - 1 No.

vi. Air release device (if required)

vii. HV bushings - 3 Nos.

viii. LV bushings - 4 Nos.

ix. Pulling lugs

x. Stiffener

xi. Radiators - No. and length may be mentioned (as per heat dissipation calculations)/ corrugations.

xii. Prismatic oil level gauge.

xiii. Drain cum sampling valve.

xiv. Top filter valve

xv. Oil filling hole having p. 1- ¼ „" thread with plug and drain plug on the conservator.

xvi. Silicagel breather

xvii. Base channel 75x40 mm for up to 100 kVA and 100 mmx50 mm above 100 kVA, 460 mm long with holes to make them suitable for fixing on a platform or plinth.

xviii. 4 No. rollers (with locking arrangement) for transformers of 200 kVA and above mounted on RCC foundation. Below 200 kVA transformer shall be channel mounted on concert pad.

xix. Pressure relief device or explosion vent.

xx. STATION TRANSFORMER (ENERGY EFFICIENCY LEVEL 2) For oil quantity more than 2000 Liters sum pit shall be provided for station service transformer.

11.32 FASTENERS:

11.32.1 All bolts, studs, screw threads, pipe threads, bolt heads and nuts shall comply with the appropriate Indian Standards for metric threads, or the technical equivalent.

11.32.2 Bolts or studs shall not be less than 6 mm in diameter except when used for small wiring terminals.

11.32.3 All nuts and pins shall be adequately locked.

11.32.4 Wherever possible bolts shall be fitted in such a manner that in the event of failure of locking resulting in the nuts working loose and falling off, the bolt will remain in position.

11.32.5 All ferrous bolts, nuts and washers placed in outdoor positions shall be treated to prevent corrosion, by hot dip galvanising, except high tensile steel bolts and spring washers which shall be electro-galvanised/plated. Appropriate precautions shall be taken to prevent electrolytic action between dissimilar metals.

11.32.6 Each bolt or stud shall project at least one thread but not more than three threads through the nut, except when otherwise approved for terminal board studs or relay stems. If bolts and nuts are placed so that they are inaccessible by means of ordinary spanners, special spanners shall be provided.

11.32.7 The length of the screwed portion of the bolts shall be such that no screw thread may form part of a shear plane between members.

11.32.8 Taper washers shall be provided where necessary.

11.32.9 Protective washers of suitable material shall be provided front and back of the securing screws.

11.33 OVERLOAD CAPACITY:

The transformers shall be suitable for loading as per IS 6600.

11.34 TESTS:

11.34.1 All the equipment offered shall be fully type tested by the bidder or his collaborator as per the relevant standards including the additional type tests. The type test must have been conducted on a transformer of same design **during the last five years** at the time of bidding. The bidder shall furnish four sets of type test reports along with the offer. **In case, the offered transformer is not type tested, the bidder will conduct the type test as per the relevant standards including the additional type tests at his own cost in CPRI/ NABL accredited laboratory in the presence of employer's representative(s) without any financial liability to employer in the event of order placed on him.**

11.34.2 **The Validity of type test report of Station Service Transformer shall be as per CEA's "Guideline for Validity period of Type Tests conducted on Major Electrical Equipment in power transmission system", file No CEA-PS-14-80/1/2019-PSETD Division- Part (2).**

11.34.3 Special tests other than type and routine tests, as agreed between purchaser and bidder shall also be carried out as per the relevant standards.

11.34.4 The requirements of site tests are also given in this clause.

11.34.5 The test certificates for all routine and type tests for the transformers, cable box and also for the bushings and transformer oil shall be submitted with the bid..

11.34.6 The procedure for testing shall be in accordance with IS1180 (Part-1) :2014 /2026 as the case may be except for temperature rise test.

11.34.7 Before dispatch each of the completely assembled transformers shall be subjected to the routine tests at the manufacturer's works.

11.35 ROUTINE TESTS:

11.35.1 Ratio, polarity, phase sequence and vector group.

11.35.2 No Load current and losses at service voltage and normal frequency.

11.35.3 Load losses at rated current and normal frequency.

11.35.4 Impedance voltage test.

11.35.5 Resistance of windings at each tap, cold (at or near the test bed temperature).

11.35.6 Insulation resistance.

11.35.7 Induced over voltage withstand test.

11.35.8 Separate source voltage withstand test.

11.35.9 Neutral current measurement-The value of zero sequence current in the neutral of the star winding shall not be more than 2% of the full load current.

11.35.10 Oil samples (one sample per lot) to comply with IS 1866.

11.35.11 Measurement of no-load losses and magnetizing current at rated frequency and 90%, 100% and 110% rated voltage.

11.35.12 Pressure and vacuum test for checking the deflection.

11.36 TYPE TESTS TO BE CONDUCTED ON ONE UNIT:

In addition to the tests mentioned in clause 30 and 31 following tests shall be conducted:

11.36.1 Temperature rise test for determining the maximum temperature rise after continuous full load run. The ambient temperature and time of test should be stated in the test certificate.

11.36.2 Impulse voltage test: with chopped wave of IS 2026 part-III.

11.36.3 **Short circuit withstand test: Thermal and dynamic ability (Dynamic Short circuit withstand test for 500 kVA and above).**

11.36.4 Air Pressure Test: As per IS – 1180 (Part-1):2014.

11.36.5 Magnetic Balance Test.

11.36.6 Un-balanced current test: The value of unbalanced current indicated by the ammeter shall not be more than 2% of the full load current.

11.36.7 Noise-level measurement.

11.36.8 Measurement of zero-phase sequence impedance.

11.36.9 Measurement of Harmonics of no-load current.

11.36.10 Transformer tank shall be subjected to specified vacuum. The tank designed for vacuum shall be tested at an internal pressure of 0.35 kg per sq cm absolute (250 mm of Hg) for one hour. The permanent deflection of flat plates after the vacuum has been released shall not exceed the values specified below:

Horizontal length of flat plate (in mm)	**Permanent deflection (in mm)**
Upto and including 750	5.0
751 to 1250	6.5

1251 to 1750	8.0
1751 to 2000	9.0

11.36.11 Transformer tank together with its radiator and other fittings shall be subjected to pressure corresponding to twice the normal pressure or 0.35 kg / sq.cm whichever is lower, measured at the base of the tank and maintained for an hour. The permanent deflection of the flat plates after the excess pressure has been released, shall not exceed the figures for vacuum test.

11.36.12 Pressure relief device test: The pressure relief device shall be subject to increasing fluid pressure. It shall operate before reaching the test pressure as specified in the above class. The operating pressure shall be recorded.
The device shall seal-off after the excess pressure has been released.

11.36.13 Short Circuit Test and Impulse Voltage Withstand Tests: The purchaser intends to procure transformers designed and successfully tested for short circuit and impulse test. In case the transformers proposed for supply against the order are not exactly as per the tested design, the supplier shall be required to carry out the short circuit test and impulse voltage withstand test at their own cost in the presence of the representative of the purchaser.

11.36.14 The supply shall be accepted only after such test is done successfully, as it confirms on successful withstand of short circuit and healthiness of the active parts thereafter on un-tanking after a short circuit test.

11.36.15 Apart from dynamic ability test, the transformers shall also be required to withstand thermal ability test or thermal withstand ability will have to be established by way of calculations.

11.37 ACCEPTANCE TESTS:

11.37.1 **All the transformers of the offered lot (100%)** shall be subjected to the following routine/ acceptance test in presence of purchaser’s representative at the place of manufacture before dispatch without any extra charges. The testing shall be carried out in accordance with IS:1180 (Part-1): 2014 and IS:2026.

11.37.2 Checking of weights, dimensions, fitting and accessories, tank sheet thickness, oil quality, material, finish and workmanship as per GTP and contract drawings.

11.37.3 Physical verification of core coil assembly and measurement of flux density of one unit of each rating, in every inspection with reference to short circuit test report.

11.37.4 Temperature rise test shall be performed on **all unit of the transformers (100%).**

11.38 TESTS AT SITE:

The purchaser reserves the right to conduct all tests on transformer after arrival at site and the manufacturer shall guarantee test certificate figures under actual service conditions.

11.39 INSPECTION:

In respect of raw material such as core stampings, winding conductors, insulating paper and oil, supplier shall use materials manufactured/supplied by standard manufacturers and furnish the manufacturers‟ test certificate as well as the proof of purchase from these manufacturers (excise gate pass) for information of the purchaser. The bidder shall furnish following documents along with their offer in respect of the raw materials:

i. Invoice of supplier.
ii. Mill's certificate.
iii. Packing list.
iv. Bill of landing.
v. Bill of entry certificate by custom.

Please refer to **"Check-list for Inspection of Prime quality CRGO for Transformers"** attached at Annexure-A. It is mandatory to follow the procedure given in this Annexure.

INSPECTION AND TESTING OF TRANSFORMER OIL**:**

11.39.1 To ascertain the quality of the transformer oil, the original manufacturer's tests report should be submitted at the time of inspection. Arrangements should also be made for testing of transformer oil, after taking out the sample from the manufactured transformers and tested in the presence of purchaser's representative.

11.39.2 To ensure about the quality of transformers, the inspection shall be carried out by the purchaser's representative at following two stages: -

11.39.2.1 **In process** anytime during receipt of raw material and manufacture/ assembly whenever the AEGCL **desires**.

11.39.2.2 At finished stage i.e., transformers are fully assembled and are ready for dispatch.

11.39.3 The stage inspection shall be carried out in accordance with **Annexure-II.**

11.39.4 After the main raw-material i.e., core and coil material and tanks are arranged and transformers are taken for productionon shop floor and a few assemblies have been completed, the firm shall intimate AEGCL in this regard, so that an officer for carrying out such inspection could be deputed, as far as possible within seven days from the date of intimation. During the stage inspection a few assembled core shall be dismantled to ensure that the laminations used are of good quality. Further, as and when the transformers are ready for dispatch, an offer intimating about the readiness of transformers, for final inspection for carrying out tests as per relevant IS shall be sent by the firm along with Routine Test Certificates.

11.39.5 In case of any defect/defective workmanship observed at any stage by the purchaser's Inspecting Officer, the same shall be pointed out to the firm in writing for taking remedial measures. Further processing should only be done after clearance from the Inspecting Officer/ purchaser.

11.39.6 All tests and inspection shall be carried out at the place of manufacture unless otherwise specifically agreed upon by the manufacturer and purchaser at the time of purchase. The manufacturer shall offer the Inspector representing the Purchaser all reasonable facilities, without charges, to satisfy him that the material is being supplied in accordance with this specification. This will include Stage Inspection during manufacturing stage as well as Active Part Inspection during Acceptance Tests.

11.39.7 The manufacturer shall provide all services to establish and maintain quality of workman ship in his works and that of his sub-contractors to ensure the mechanical

/electrical performance of components, compliance with drawings, identification and acceptability of all materials, parts and equipment as per latest quality standards of ISO 9000.

11.39.8 Purchaser shall have every right to appoint a third-party inspection to carry out the inspection process.

11.39.9 The purchaser has the right to have the test carried out at his own cost by an independent agency wherever there is a dispute regarding the quality supplied. Purchaser has right to test 1% of the supply selected either from the stores or field to check the quality of the product. In case of any deviation purchaser have every right to reject the entire lot or penalize the manufacturer, which may lead to blacklisting, among other things.

11.40 QUALITY ASSURANCE PLAN:

11.40.1 The bidder shall invariably furnish following information along with the bid, failing which his bid shall be liable for rejection. Information shall be separately given for individual type of equipment offered.

11.40.2 Statement giving list of important raw materials, names of sub-suppliers for the raw materials, list of standards according to which the raw materials are tested, list of tests normally carried out on raw materials in the presence of bidder's representative, copies of test certificates.

11.40.3 Information and copies of test certificates as above in respect of bought out accessories.

11.40.4 List of manufacturing facilities available.

11.40.5 Level of automation achieved and list of areas where manual processing exists.

11.40.6 List of areas in manufacturing process, where stage inspections are normally carried out for quality control and details of such tests and inspection.

11.40.7 List of testing equipment available with the bidder for final testing of equipment along with valid calibration reports. These shall be furnished with the bid. Manufacturer shall posses 0.1 accuracy class instruments for measurement of losses.

11.40.8 Quality Assurance Plan (QAP) withhold points for purchaser's inspection.

11.40.9 The successful bidder shall within 30 days of placement of order, submit following information to the purchaser:

11.40.9.1 List of raw materials as well as bought out accessories and the names of sub-suppliers selected from those furnished along with offer.
11.40.9.2 Type test certificates of the raw materials and bought out accessories.
11.40.9.3 The successful bidder shall submit the routine test certificates of bought out accessories and central excise passes for raw material at the time of routine testing.

11.41 DOCUMENTATION:

11.41.1 The bidder shall furnish along with the bid the dimensional drawings of the items offered indicating all the fittings.

11.41.2 Dimensional tolerances.

11.41.3 Weight of individual components and total weight.

11.41.4 An outline drawing front (both primary and secondary sides) and end-elevation and plan of the tank and terminal gear, wherein the principal dimensions shall be given.

11.41.5 Typical general arrangement drawings of the windings with the details of the insulation at each point and core construction of **transformer and terminals to be connected to the bushings.**

11.41.6 Typical general arrangement drawing showing both primary and secondary sides and end- elevation and plan of the transformer.

11.42 PACKING AND FORWARDING:

11.42.1 The packing shall be done as per the manufacturer's standard practice. However, it should be ensured that the packing is such that, the material would not get damaged during transit by Rail / Road / Sea.

11.42.2 The marking on each package shall be as per the relevant IS.

11.43 GUARANTEE

11.43.1 The manufacturers of the transformer shall provide a guarantee of 24 months from the date of receipt at the stores of the Utility or 18 months from the date of commissioning, whichever is earlier. In case the distribution transformer fails within the guarantee period the purchaser will immediately inform the supplier who shall take back the failed DT within 15 days from the date of the intimation at his own cost and replace/repair the transformer within forty-five days of date of intimation with a roll over guarantee.

11.43.2 The outage period i.e., period from the date of failure till unit is repaired/ replaced shall not be counted for arriving at the guarantee period.

11.43.3 In the event of the supplier‟s inability to adhere to the aforesaid provisions, suitable penal action will be taken against the supplier which may inter alia include blacklisting of the firm for future business with the purchaser for a certain period.

11.44 SCHEDULES:

The bidder shall fill in the following schedule which will be part of the offer. If the schedule are not submitted duly filled in with the offer, the offer shall be liable for rejection.

Schedule-A : Guaranteed Technical Particulars

Schedule-B : Schedule of Deviations

11.45 DEVIATIONS:

11.45.1 The bidders are not allowed to deviate from the principal requirements of the Specifications. However, the bidder is required to submit with his bid in the relevant schedule a detailed list of all deviations without any ambiguity. In the absence of a deviation list in the deviation schedules, it is understood that such bid conforms to the bid specifications and no post-bid negotiations shall take place in this regard.

11.45.2 The discrepancies, if any, between the specification and the catalogues and / or literatures submitted as part of the offer by the bidders, shall not be considered and representations in this regard shall not be entertained.

11.45.3 If it is observed that there are deviations in the offer in guaranteed technical particulars other than those specified in the deviation schedules then such deviations shall be treated as deviations.

11.45.4 **All the schedules shall be prepared by vendor and are to be enclosed with the bid.**

Annexure – II

PROFORMA FOR STAGE INSPECTION OF DISTRIBUTION TRANSFORMERS

(A) GENERAL INFORMATION:

1. Name of firm : M/s.
2. Order No. and Date :
3. Rating-wise quantity offered :
4. Details of offer
   a) Rating
   b) Quantity
   c) Serial Numbers
5. Details of last stage inspected lot:
   a) Total quantity inspected
   b) Serial Numbers
   c) Date of stage inspection
   d) Quantity offered for final inspection of
      (a) above with date

(B) **Availability of material for offered quantity** :

Details to be filled in

(C) Position of manufacturing stage of the offered quantity:

a) Complete tanked assembly
b) Core and coil assembly ready
c) Core assembled
d) Coils ready for assembly
   (i) HV Coils
   (ii) LV Coils

Note: (i) A quantity of more than 100 Nos. shall not be entertained for stage inspection.

(ii) The stage inspection shall be carried out in case :-

(a) At least 25% quantity offered has been tanked and

(b) core coil assembly of further at least 30% of the quantity offered has been completed.

(iii) Quantity offered for stage inspection should be offered for final Inspection within 15 days from the date of issuance of clearance for stage inspection, otherwise stage inspection already cleared shall be liable for cancellation.

Sl. No	Particulars	As offered	As observed	Deviation and Remarks
(D)	**Inspection of Core**: (I) **Core Material** (1) Manufacturer's Characteristic Certificate in respect of grade of lamination used. (Please furnish test certificate)			
	(2) Remarks regarding Rusting and smoothness of core.			
	(3) Whether laminations used for top and bottom yoke are in one piece.			

	(II) **Core Construction:**											
	(1) No. of Steps											
	(2) Dimension of Steps											
	Step No.	1	2	3	4	5	6	7	8	9	10	11 12
	As offered:											
	W mm											
	T mm											
	As found:											
	W mm											
	T mm											
	(3) Core Dia (mm)											
	(4) Total cross Section area of core											
	(5) Effective cross-Sectionalarea of core											
	(6) Clamping arrangement											
	(i) Channel Size											
	(ii) Bolt size and No.											
	(iii) Tie Rods size and No.											
	(iv) **Painting**											
	(a) Channels											
	(b) Tie Rods											
	(c) Bolts											
	(7) Whether top yoke is cut for LV connection.											
	(8) If yes, at 7 above, whether Reinforcement is done.											
	(9) Size of Support Channels provided for Core base and bottom yoke (Single piece of channels are only acceptable) .											
	(10) Thickness of insulation provided between core base and support channel.											
	(11) core length (leg center to leg center)											
	(12) Window height											
	(13) Core height											

	(14) Core weight only (without channels etc.)			
(E)	**INSPECTION OF WINDING**			
	(I) Winding material			
	(1) Material used for			
	(a) HV winding			
	(b) LV winding			
	(2) Grade of material for			
	(a) HV winding			
	(b) LV winding			
	3) Test certificate of manufacturer (enclose copy) for winding material of:			
	(a) HV			
	(b) LV			
	(II) CONSTRUCTIONAL DETAILS (1) Size of Cross Sectional area of conductor for :			
	(a) HV winding			

	(b) LV winding			
	(2) Type of insulation for conductor of :			
	a) HV winding			
	(b) LV winding			
	(3) Diameter of wire used for delta formation (mm)			
	(4) Diameter of coils in:			
	a) LV winding			
	i) Internal dia (mm)			
	ii) Outer dia (mm)			
	b) HV winding			
	i) Internal dia (mm)			
	ii) Outer dia (mm)			

	(5) Current Density of winding material used for :			
	(a) HV			
	(b) LV			
	(6) Whether neutral formation on top.			
	(7) HV Coils/ Phase			
	a) Number			
	b) Turns / coil			
	c) Total turns			
	(8) LV Coils/ Phase			
	a) Number			
	b) Turns / coil			
	c) Total turns			
	(9) Method of HV Coil Joints			
	(10) Total weight of coils of			
	a) LV winding (kg)			
	b) HV winding (kg)			
(F)	**INSULATION MATERIALS** :			
	(I) **MATERIAL** :			
	1) Craft paper			
	a) Make			
	b) Thickness (mm)			
	c) Test Certificate of manufacturer (enclose copy).			
	2) Press Board			
	a) Make			
	b) Thickness (mm)			
	c) Test Certificate of manufacturer (enclose copy).			
	3) Material used for top and bottom yoke and insulation			
	(II) **Type and thickness of material used** : (mm)			

	a) Between core and LV			
	b) Spacers			
	c) Inter layer			
	d) Between HV and LV winding			
	e) Between phases			
	f) End insulation			
(G)	**CLEARANCES** : (mm)			
	(I) **Related to core and Windings**			
	1) LV to Core (Radial) 2) Between HV and LV (Radial)			
	3) (i) Phase to phase between HV Conductor			
	(ii) Whether two Nos. Press Board each of minimum 1 mm thick provided to cover the tie rods.			
	4) Thickness oflocking spacers between LV coils (mm)			
	5) Axial wedges between HV and LV coils / phase (Nos.)			
	6) No. of radial spacers per phase between HV coils			
	7) Size of duct between LV and HV winding (mm)			
	(II) **Between core - coil assembly and tank** : **(mm)**			
	1) Between winding and body:			
	a) Tank lengthwise			
	b) Tank Breadth wise			
	2) Clearance between top cover and top yoke upto 100 kVA and between top cover and top most live part of tap changing switch for 200 kVA and above.			

(H)	**TANK** : (I) **Constructional details** : 1) Rectangular shape 2) Thickness of side wall (mm) 3) Thickness of top and bottom plate (mm) 4) Provision of slopping top cover towards HV bushing.			
	5) Tank internal dimensions (mm)			
	a) Length			
	b) Breadth			
	c) Height (i) On LV side (ii) On LV side			
	(II) **General details** :			
	1) Inside painted by varnish/ oil corrosion resistant paint			
	please specify which type of coating done).			
	2) Gasket between top cover and tank i) Material			
	ii) Thickness (mm)			
	iii) Jointing over laps (mm) 3). Reinforcement of welded angle (specify size and No. of angle			
	side walls of tank.			
	4) Provision of lifting lugs:			
	b) Whether lugs of 8 mm thick MS Plate provided c) Whether reinforced by welded plates edge wise below the lug upto re- enforcing angle of the			
	5) Pulling lug of MS Plate a) Nos.			
	b) Thickness (mm) c) Whether provided on breadth side or length side 6) Provision of air release plug			
	7) Provision of galvanized GI Nuts Bolts with 1 No. Plain and 1 No. spring washer.			
	8) Deformation of length wise side wall of tank when subject to: a) Vacuum of (-) 0.7 kg/sq cm for 30 minutes.			

Sl. No	Particulars	As offered	As observed	Deviation and Remarks
	b) Pressure of 0.8 kg/sq cm for 30 minutes.			
(I)	**RAIDATORS** :			
	1. Fin Radiators of 1.25 mm thick Sheet			
	a) Dimension of each fin (LxBxT)			
	b) Fins per radiator			
	c) Total No. of radiators			
	2. Verification of manufacturer"s test certificate regarding Heat dissipation (excluding Top and Bottom) in w/sq m			
	3. Verification of position of radiator with respect to bushing.			
(J)	**CONSERVATOR** :			
	1. Dimensions (L x D) (in mm)			
	2. Volume (m^3)			
	3. Inside dia of Conservator tank pipe (mm)			
	4. Whether conservator outlet pipe is projected approx. 20 mm inside the conservator tank.			
	5. Whether arrangement made so that oil does not fall on the active parts.			
	6. Whether die cast metal oil level gauge indicator having three positions at (- 5^o C, 30 ^{o} C and 98 ^{o}C) is provided .			
	7. Whether drain plug and filling hole with cover is provided.			
	8. Inner side of the conservator Tank painted with-			
(K)	**BREATHER** :			
	1. Whether Die cast Aluminium body breather for silica gel provided.			
	2. Make			
	3. Capacity			

Sl. No **(L)**	Particulars **TERMINALS:**	As offered	As observed	Deviation and Remarks
	1. Material whether of Brass Rods/ Tinned Copper.			
	a) HV			
	b) LV			
	2. Size (dia in mm)			
	a) HV			
	b) LV			
	3. Method of Star connection formed on LV side of 6mm thick (Should use Al./Cu. Flat bolted/ brazed with crimped lugs on winding alternatively for 63 and 100 kVA ratings brazing is done covered with tubular sleeve duly crimped). - Please state dimensions of Al/ Cu flat or tubular sleeve used. (mm)			
	4. Method of Connection of LV winding to LV Bushing (end of winding should be crimped with lugs (Al/Cu) and bolted with bushing stud).			
	5. Method of Connection of HV winding to HV bushing (Copper joint should be done by using silver brazing alloy and for Aluminium, brazing rod or with tubular connector crimped at three spots).			
	6. Whether SRB Ptube/insulated paper used for formation of Delta on HV.			
	7. Whether Empire sleeves used on the portion of HV winding joining to HV bushing.			
	8. Whether neutral formation is covered with cotton tape			
(M)	**BUSHINGS** :			
	1. Whether HV bushings mounted on side walls. 2. Whether sheet metal pocket used for mounting bushing			
	(pipe are not acceptable)			
	a) HV			
	b) LV			

	3. Whether arrangement for studs for fitting of HV Bushing are in diamond shape (so that Arcing Horns are placed vertically).			
	4. Position of mounting of LV bushings.			
	5. Bushing Clearance: (mm)			
	a) LV to Earth			
	b) HV to Earth			
	c) Between LV Bushings			
	d) Between HV Bushings			
(N)	**TANK BASE CHANNEL /**			
	ROLLERS :			
	1. Size of channel (mm)			
	2. Whether channels welded across the length of the tank			
	3. Size and type of roller (mm)			
(O)	**OIL** :			
	1. Name of supplier			
	2. Break down voltage of oil: (kV)			
	i) Filled in tanked transformer			
	ii) In storage tank (to be tested by Inspecting Officer).			
	3. Supplier"s test certificate(enclose copy)			
(P)	**ENGRAVING** :			
	1. Engraving of Sl. No. and name of firm.			
	i) On bottom of clamping channel of core-coil assembly.			
	ii) On side wall and top cover of tank along with date of despatch.			
(Q)	i) MS plate of size 125x125 mm welded on width side of stiffner			
	ii) Following details engraved (as per approved GTP):			
	(a) Serial Number			
	(b) Name of firm			
	(c) Order No. and Date			
	(d) Rating			
	(e) Name of Inspecting Officer			
	(f) Designation			
	(g) Date of dispatch			
(R)	**NAME PLATE DETAILS** :			
	Whether Name Plate is as per approved drawing			
(S)	**Colour of Transformer**			
	1. Tank body with dark Green colour			
	2. Conservator with white colour			
(T)	**CHECKING OF TESTING FACILITIES**:			
	(Calibration certificate also to be checked for its validity)			
	TESTS:			
	1. No Load Current			
	2. No Load Loss			
	3. % Impedance			
	4. Load Losses			
	5. Insulation Resistance Test			
	6. Vector Group Test (phase relationship)			

	7. Ratio and Polarity test relationship			
	8. Transformer Oil Test (Break Down Voltage)			
	9. Magnetic Balance			
	10. Measurement of winding resistance (HV and LV both)			
	11. Induced over voltage withstand test (Double voltage and Double frequency)			
	12. Separate source power frequency withstandtestat28kVforHVand3kVforLV(one minute).			
	13. Air pressure/ Oil leakage Test			
	14. Vacuum test			
	15. Unbalanced current test			
	16. Temperature rise (Heat Run) test.			
(U)	We have specifically checked the following and found the same as per G.T.P./deviations observed as mentioned against each:			
	i) Rustlessness of CRGO laminations used			
	ii) Core steps			
	iii) Core area			
	iv) Core weight			
	v) Winding cross sectional area			
	a) LV			
	b) HV			
	vi) Weight of windings			
	vii) Clearance between winding and wall of tank (mm)			
	a) Length-wise			
	b) Breadth-wise			
	viii) Clearance between top of yoke/ top most live part of tap changer to tank cover.			
	ix) Details of Neutral formation			
	x) Connections to bushings:			
	a) LV			
	b) HV			
	xi) Slope of tank top			
	xii) Position of mounting of bushings			

Annexure - A

Check-list for Inspection of Prime quality CRGO for Transformers

During inspection of PRIME CRGO, the following points needs to be checked by the Transformer manufacturer. Utilitity's inspector shall verify all these points during inspection: -

A) **In case PRIME CRGO cutting is at works of Transformer Manufacturer:**

1 Review of documents:

- Purchase Order (unpriced) to PRIME CRGO supplier/Authorised Agency
- Manufacturer's test certificate
- Invoice of the Supplier
- Packing List
- Bill of Lading
- Bill of Entry Certificate by Customs Deptt.
- Reconciliation Statement as per format below
- Certificate of Origin
- BIS Certification

Format for Reconciliation/Traceability records

Packing List No./date /Quantity of PRIME CRGO received Name of Manufacturer

Manufacturer test certificate No./date

Serial No.	Details of Package/Job	Drawing Reference	Quantity involved	Cumulative Quantity Consumed	Balance in Stock

2 .1 Inspection of PRIME CRGO Coils:

a. PRIME CRGO-Manufacturer's Identification Slip on PRIME CRGO Coils
b. Visual Inspection of PRIME CRGO Coils offered as per packing list (for verification of coil details as per Test certificate & healthiness of packaging).
c. Unique numbering inside of each sample of PRIME CRGO coil and verification of records to be maintained in the register for consumption of CRGO coil.
d. ISI logo sticker on packed mother coil and ISI logo in Material TC.

2.2. During inspection of PRIME CRGO, surveillance testing of sample shall be carried out for Stacking Factor, Permeability, Specific watt loss at 1.5 Tesla and/or 1.7 Tesla depending on the grade of PRIME CRGO and aging test etc.

applicable as per relevant IS/ IEC standard, Tech. Spec., MQP and Transformer manufacturer plant standard.

Inspection Clearance Report would be issued after this inspection

3 Inspection of PRIME CRGO laminations: Transformer manufacturer will maintain records for traceability of laminations to prime CRGO coils and burr/bow on laminations shall be measured. Utility can review these records on surveillance basis.

4. Inspection at the time of core building:

Visual Inspection of PRIME CRGO laminations. In case of suspected mix-up/ rusting/decoloration, samples may be taken for testing on surveillance basis for tests mentioned in A.2.2 above.

Above tests shall be witnessed by Utility. In case testing facilities are not available at Manufacturer's work, the sample(s) sealed by Utility to be sent to approved labs for testing.

Inspection Clearance Report would be issued after this inspection

B) **In case PRIME CRGO cutting is at Sub-vendor of Transformer Manufacturer:**

1 Review of documents:
- Purchase Order (unpriced) to PRIME CRGO supplier/ Authorised Agency
- Purchase Order (unpriced) to Core Cutter
- Manufacturer test certificate
- Invoice of the Supplier
- Packing List
- Bill of Lading
- Bill of Entry Certificate by Customs Deptt.
- Reconciliation Statement as per format below
- Certificate of origin
- BIS Certification

Format for Traceability records as below: -

Packing List No./date /Quantity of PRIME CRGO received Name of Manufacturer

Manufacturer test certificate No./date

Serial No.	Name of Customer	Details of Package/Job	Drawing Reference	Quantity involved	Cumulative Quantity Consumed	Balance in Stock	Dispatch details

2 .1 Inspection of PRIME CRGO Coils:

a. PRIME CRGO-Manufacturer's Identification Slip on PRIME CRGO Coils
b. Visual Inspection of PRIME CRGO Coils offered as per packing list (for verification of coil details as per Test certificate & healthiness of packaging).
c. Unique numbering inside of each sample of PRIME CRGO coil and verification of records to be maintained in the register for consumption of CRGO coil.
d. ISI logo sticker on packed mother coil and ISI logo in Material TC.

2.2. During inspection of PRIME CRGO, surveillance testing of sample shall be carried out for Stacking Factor, Permeability, Specific watt loss at 1.5 Tesla and/or 1.7 Tesla, thickness depending on the grade of PRIME CRGO and aging test etc. applicable as per relevant IS/ IEC standard, Tech. Spec., MQP and Transformer manufacturer plant standard.

3.0 INSPECTION CLEARANCE REPORT WOULD BE ISSUED AFTER THIS INSPECTION

3.1 Inspection of PRIME CRGO laminations

Transformer manufacturer representative will inspect laminations and issue their internal Inspection Clearance Report. Inspection will comprise of review of traceability to prime CRGO coils, visual Inspection of PRIME CRGO laminations and record of burr/bow. After clearance given by transformer manufacturer, Utility will issue an Inspection Clearance Report after record review. If so desired by Utility, their representative may also join transformer manufacturer representative during this inspection.

Inspection Clearance Report would be issued after this inspection

3.2 Inspection at the time of core building:

Visual Inspection of PRIME CRGO laminations. In case of suspected mix-up/rusting/decoloration, samples may be taken for testing on surveillance basis for tests mentioned in B.2.2.

Inspection Clearance Report would be issued after this inspection

NOTE :-

a) Transformer Manufacturer to ensure that PRIME CRGO is procured from reputed vendors and CRGO manufacturer should have valid BIS Certificate for respective offered Grade.

b) Transformer Manufacturer should also involve themselves for ensuring the quality of CRGO Laminations at their Core Cutter's works. They should visit the works of their Core cutter and carry out necessary checks.

Sampling Plan (PRIME CRGO)

33 kV	-1st transformer and subsequently at random 10% of Transformers (min. 1) offered for inspection.
DTs and other ratings	-1st transformer and subsequently at random 2% of Transformers (min. 1) offered for inspection.

NOTE: - One sample for each lot of CRGO shall be drawn on surveillance basis.

CRGO has to be procured only from Reputed vendors.

CHAPTER 12: TECHNICAL SPECIFICATION FOR 398KV, 198KV, 120KV & 30KV SURGE ARRESTER

TECHNICAL SPECIFICATION FOR SURGE ARRESTERS FOR 400KV, 220KV, 132KV & 33KV SYSTEMS

12.1.0. SCOPE

12.1.1. **This Section covers the specifications for design, manufacture, testing, transportation delivery at site, erection, and commissioning of class heavy duty, gapless metal (zinc) oxide Surge Arrestors complete with fittings & accessories for 400 kV, 220 kV, 132 kV and 33 kV systems.**

12.2.0. STANDARDS

12.2.1. The design, manufacture and performance of Surge Arrestors shall comply with IS: 15086 Part-4 / IEC: 60099-4 unless otherwise specifically specified in this Specification

12.3.0. GENERAL REQUIREMENT

12.3.1. The surge arrestor shall draw negligible current at operating voltage and at the same time offer least resistance during the flow of surge current. **The surge arrester shall be used in solidly earthed system**.

12.3.2. The surge arrestor shall consist of non-linear resistor elements placed in series and housed in electrical grade porcelain housing of specified creepage distance.

12.3.3. The assembly shall be hermetically sealed with suitable rubber gaskets with effective sealing system arrangement to prevent ingress of moisture.

12.3.4. The surge arrestor shall not operate under power frequency and temporary over voltage conditions but under surge conditions, the surge arrestor shall change over to the conducting mode.

12.3.5. The surge arrestor shall be suitable for circuit breaker performing 0-0.3sec.-CO-3min-CO- duty in the system.

12.3.6. Surge arrestors shall have a suitable pressure relief system to avoid damage to the porcelain
housing and providing path for flow of rated fault currents in the event of arrestor fail ure..

12.3.7. The reference current of the arrestor shall be high enough to eliminate the influence of grading and stray capacitance on the measured reference voltage.

12.3.8. The Surge Arrestor shall be thermally stable and the bidder shall furnish a copy of thermal stability test with the bid.

12.3.9. The arrestor shall be capable of handling terminal energy for high surges, external pollution and transient over voltage and have low losses at operating voltages.

12.4.0. ARRESTOR HOUSING

12.4.1. The arrestor housing shall be made up of porcelain housing and shall be homogenous, free from laminations, cavities and other flaws of imperfections that might affect the mechanical and dielectric quality. The housing shall be of uniform brown colour, free from blisters, burrs and other similar defects.

Arrestors shall be complete with insulating bases, fasteners for stacking units together, surge counters with leakage current meters and terminal connectors.

12.4.2. The **housing shall be so coordinated that external flashover shall not occur due to application of** any impulse or switching surge voltage up to the maximum design value for arrestor. The arrestors shall not fail due to contamination. The arrester housings shall be designed for pressure relief class as given in Technical Parameters of the specification.

12.4.3. Sealed housings shall exhibit no measurable leakage.

12.5.0. FITTINGS & ACCESSORIES

12.5.1. The surge arrestor shall be complete with insulating bases, fasteners for stacking units together, surge counters with leakage current meters and terminal connectors.

12.5.2. The terminals shall be non-magnetic, corrosion proof, robust and of adequate size and shall be so located that incoming and outgoing connections are made with minimum possible bends. The top metal cap and base of surge arrestor shall be galvanized. The line terminal shall have a built-in clamping device which can be adjusted for both horizontal and vertical takeoff.

12.5.3. Grading corona control rings if necessary, shall be provided on each complete arrestor pole for proper stress distribution.

12.6.0. SURGE MONITOR

12.6.1. A self-contained discharge counter suitably enclosed for outdoor use and requiring no auxiliary or battery supply for operation shall be provided for each single pole unit. Leakage current meter with scale range **of 0 to 5mA peak/root 2 to** measure leakage current of surge arrestor shall also be supplied within the same enclosure. The number of operations performed by the arrestor shall be recorded by a suitable non-resettable cyclometric counter and surge monitor shall be provided with an inspection window. There shall be a provision for putting ammeter to record the current/alarm contacts suitable for communication to SCADA in the control room if the leakage current exceeds the permitted value. Similar provision shall be considered for surge counter also.

12.6.2. Surge monitor shall be mounted on the support structure at a suitable height so that the reading can be taken from ground level through the inspection window and length of connecting leads of **minimum 5kV rating** up to grounding point and bends shall be minimum.

12.7.0. TESTS

12.7.1. **Test on Surge Arrestors**

The Surge Arrestors offered shall be type tested and shall be subjected to routine and acceptance tests in accordance with IS: 15086 (Part-4). In addition, the suitability of the Surge Arrestors shall also be established for the following:

- Residual voltage test
- Reference voltage test
- Leakage current at M.C.O.V
- P.D. test
- Sealing test
- Thermal stability test
- Aging and Energy capability test

- Watt loss test

Each metal oxide block shall be tested for guaranteed specific energy capability in addition to routine/acceptance test as per IEC/IS.

12.7.2. The surge arrestor housing shall also be type tested and shall be subjected to routine and acceptance tests in accordance with IS: 2071.

12.7.3. Galvanization Test

All Ferrous parts exposed to atmospheric condition shall have passed the type tests and be subjected to routine and acceptance tests in accordance with IS: 2633 & IS 6745.

12.8.0. NAME PLATE

12.8.1. The name plate attached to the arrestor shall carry the following information:

Rated Voltage

Continuous Operation Voltage

Normal discharge current

Pressure relief rated current

Manufacturers Trade Mark

Name of Sub-station

Year of Manufacturer

Name of the manufacture

Purchase Order Number along with date.

Energy Absorption Capability

12.9.0. PRE-COMMISSIONING TESTS

12.9.1. Contractor shall carry out following tests as pre-commissioning tests. Contractor shall also perform any additional test based on specialties of the items as per the field 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.

(a) Operation check of LA counters.
(b) Insulation resistance measurement.
(c) Third harmonic resistive current measurement (to be conducted after energisation.)

12.10.0. TYPE AND RATINGS may be read as:

SL No.	Particulars	420 kV	245 kV	145 kV	36 kV
I	**II**	**III**	**IV**	**V**	**VII**
1	Rated voltage of arrester, kV	398	216	120	30
2	Continuous operating voltage,	267	168	102	25

	kV				
2	Rated frequency, Hz	50	50	50	50
3	Nominal discharge current of arrester, kA	20	20/10	10	10
4	(i) Min. switching surge residual voltage (2kA),kVp	IEC	IEC	IEC	IEC
	(i) Max. switching surge residual voltage (500 kA),kVp	IEC	IEC	IEC	IEC
5	Maximum residual voltage at,				
	(i) 5 kA nominal discharge current, kV (peak)	IEC	IEC	IEC	IEC
	(ii) 10kA nominal discharge current, kV (peak)	IEC	IEC	IEC	IEC
	(iii) 20kA nominal discharge current, kV (peak)	IEC	IEC	IEC	IEC
	(iv) Steep fronted wave residual voltage, kV (peak)	IEC	IEC	IEC	IEC
6	One minute power frequency withstand voltage of arrester housing, kV (rms)	650	460	275	70
7	1.2 / 50 □ second impulse withstand voltage of arrester housing, kV (peak)	1425	1050	650	170
8	Switching impulse withstand voltage (250/2500 micro second) of arrester housing dry and wet, kV (peak)	1050	-	-	-
9	Creepage distance of insulator housing (mm)	13020	7595	4495	1116
10	Line discharge class	4	3	3	3
11	Short time current rating, kA for 3 sec	63	50	40	31.5
12	Pressure Relief Class	A	A	A	A
13	Minimum cantilever strength (upright)	10kN	8N	6KN	4KN

CHAPTER 13: TECHNICAL SPECIFICATION FOR 33 KV, 132KV, 220KV & 400 KV CVT & IVT

13.1. SCOPE:

13.1.1. This specification provides for the design, manufacture, assembly inspection and testing at the manufacturer's works, packing and delivery at site, erection, testing and commissioning of outdoor mounted type, single phase, oil filled, self-cooled, single unit type Inductive voltage transformers for 33 KV &132KV systems, & Capacitive Voltage Transformers for,132KV, 220kV & 400 KV system to be used for voltage indication, supply of potential to energy meters, relays for feeder protection in Grid Sub- stations of AEGCL, ASSAM.. In addition to the above functions the 400 KV, 220kV, 132KV CVT shall be suitable for carrier coupling.

13.1.2. The IVTs shall be complete in all respects with insulators, bimetallic connectors, fixing details etc. as described herein.

13.1.3. Bidders are required to quote for 0.2 accuracy class [metering winding] for 33 KV and 132KV IVTs & 132KV, 220kV, 400kV CVTs in the following manner.

(a) Guaranteed Technical Particulars.

(b) Technical literatures, brochures and drawings as per this specification.

(c) Type Test reports.

(d) List of orders, executed and Users' certificates with **minimum 5years of field proven experience** failing submission of the above particulars with the offer, the tender may not be considered for evaluation.

13.2. Following is the list of documents constituting this Specification:

(i) Technical Specification (TS).

(ii) Technical requirements.

13.3. STANDARDS:

13.3.1 The IVTs & CVTs shall conform in all respects to high standards of Engineering, design, workmanship and latest revisions of relevant standards at the time of offer and the Purchaser shall have the power to reject any work or material which in his judgement is not in full accordance therewith.

13.3.2. Except to the extent modified in the specifications, the IVTS & CVTs shall conform to the latest editions and the amendments of the standards listed hereunder:

Sl. No.	Standard Ref. No.	Title
01	IEC-44(4)	Instrument Transformer – measurement of PDS.
02	IEC-60	High voltage testing techniques.
03	IEC-171	Insulation co-ordination.
04	IEC-186	Voltage Transformers.
05	IEC-186(A)	Voltage Transformers (first supp. to IEC-186)
06	IEC-270	Partial discharge measurement.
07	IS-335	Insulating oil for transformers and switchgears.
08	IEC-8263	Method for RIV Test on high voltage insulators.

09	IS-2071	Method of high voltage testing.
10	IS-2099	High Voltage porcelain bushings.
11	IS-2147	Degree of protection provided by enclosures for low voltage switchgear and control.
12	IS-2165	Insulation co-ordination for equipments of 100KV and above.
13	IS-3156 (Part-I to IV).	Voltage transformers.
14	IS-3347	Dimensions of porcelain transformer bushings.
15	IS-4146	Application guide for voltage transformers.
16	IS-5547	Application guide for Capacitor Voltage Transformers.
17	IS-9348	Coupling Capacitor & Capacitor Devices.

13.3.3 All the above along with the amendments thereof shall be read and interpreted together. However, in case of a contradiction between the Technical Specification and any other volume, the provisions of this Technical Specification will prevail.

13.3.4. The voltage transformers with the requirements of other authoritative standards, which ensure equal or better quality than the standards, mentioned above shall also be acceptable. Where the equipments, offered by the supplier conform to other standards, salient points of difference between the standards shall be brought out in the offer. 4 (four) copies of the reference standards in English language shall be furnished along with the offer.

13.3.5. **The supplier is to furnish the standards as mentioned above from Sl. 1 to 17 at their own cost, if required by the purchaser.**

13.3.6: **Accuracy specified shall be maintained at 25% of rated burden.**

13.4. CLIMATIC AND SERVICE CONDITIONS:

13.4.1 Earthquake Incidence:

The CVT/VT are to be designed to withstand earthquake of intensity, equivalent to **minium** 0.5g in the horizontal and 0.6g in the vertical direction.

13.5. INSTALLATION:

The **CVT**/VT covered under this specification shall be suitable for outdoor installation without any protection from rain, dust, mist and direct rays of the sun.

13.6. GENERAL TECHNICAL REQUIREMENTS:

13.6.1. GENERAL TECHNICAL REQUIREMENTS FOR IVT:

13.6.1.1. Each IVT shall be supplied, filled with insulating oil and shall be hermetically sealed to prevent **atmospheric environment** in contact with oil, avoiding filtration and change of oil. Stainless steel diaphragm Bellow with bellow level indicator shall be provided.

13.6.1.2. Secondary Terminal Box:

13.6.1.2.1. The secondary terminals shall be brought out in a weatherproof terminal box with IP-55 **degree of protection enclosure.**

13.6.1.2.2 All secondary terminals shall be brought out in a compartment on one side of each IVT for easy access.

13.6.1.2.3. The exterior of this terminal box shall be hot dip galvanized.

13.6.1.2.4. The terminal box shall be provided with removable gland plate and glands suitable for 1100 volts grade. PVC insulated, PVC sheathed multi core of **2.5 sq.mm to 4 sq.mm** stranded copper conductor cable.

13.6.1.2.5. The terminal box shall be provided with a cover in front so as to have easy access of secondary terminals. The cover shall have a sealing/locking arrangement and shall be suitable to prevent penetration of moisture and rainwater.

13.6.1.2.6. The dimensions of the terminal box and its openings shall be adequate to enable easy access and sufficient working space for use of normal tools.

13.6.1.2.7. The terminal blocks shall be standard type and provided with ferrules indelibly marked or numbered and their identifications shall correspond to the designation on the relevant wiring diagram.

13.6.1.2.8. Secondary wiring terminal studs shall be provided with at least three nuts, plain and spring washers. The studs, nuts and washers shall be of brass, duly nickel plated. The minimum diameter of the studs shall be 6 mm. The length of at least 15 mm shall be available on the studs for inserting the leads.

13.6.1.2.9. Primary earthling link should be provided for measurement of capacitance & di-electric dissipation factor.

13.6.1.2.10 Polarity shall be indelibly marked on each primary and secondary terminal.

13.6.1.3 The IVT shall be vacuum filled with oil after processing and thereafter hermetically sealed to eliminate breathing and to prevent air and moisture from entering the tanks. The method adopted for hermetic sealing shall be described in the offer.

13.6.1.4. The castings of base, collar etc. shall be die cast and tested before assembly to detect cracks and voids, if any.

13.6.1.5. The characteristics of the IVTS shall be such as to provide satisfactory performance such as voltage error and phase displacement at rated frequency shall not exceed the values as per relevant standards at any voltage between 80% and 120% of rated voltage and with burdens of between 25% and 100% of rated burden at a power factor of 0.8 lagging. The error shall be determined at the terminals of the IVT and shall include the effects of any fuses or resistors as an integral part of the IVT.

13.6.1.6. Inductive voltage transformers shall be ferro-resonance proof and adequately designed to use in HT cable circuit wherever applicable.

13.6.1.10. Primary Winding:

Primary winding of the IVT will be connected phase to neutral with the neutral point solidly earthed. The arrangement for this shall be included in the scope of supply. The primary conductor shall be of adequate cross-section so that the maximum permissible current density shall not be exceeded even during short-circuit conditions. Primary Windings shall be made of Copper.

13.6.1.11. Secondary Winding:

Suitably insulated copper wire of electrolytic grade shall be used for secondary windings. The secondary conductor shall be of adequate cross section so that the maximum permissible current density shall not be exceeded even during short- circuit conditions. Secondary windings details, burden & accuracy class are mentioned in Appendix-I. Secondary windings shall be used for metering, relaying and synchronizing. Each winding shall comply requirements of both Part-II and III of up-to-date editions of IS-3156/IEC-186.

13.6.1.12. Core:

Core laminations shall be of cold rolled grain-oriented silicon steel to ensure 0.2 accuracy class at both normal and over voltage. The core material, thickness of lamination, the relevant graphs showing the characteristics of the core materials shall be submitted along with the offer.

13.6.1.13. Tank:

13.6.1.13.1. Both expansion chambers and tanks of the IVT shall be made of high-quality steel and shall be able to withstand full vacuum and pressure, and thermal and mechanical stresses resulting from maximum short circuit current during operation. The tanks along with all ferrous parts shall be hot- dip galvanized as per relevant standard.

13.6.1.13.2. The metal tanks shall have bare minimum number of welded joints so as to minimize possible locations of oil leakage. Welding in horizontal plane is to be avoided. Supplier has to obtain specific approval from the purchaser for any horizontal welding, used in the bottom tank

13.6.1.13.3. Paint inside the metallic housing shall be of anti-condensation type.

13.6.1.14. Porcelain Housing:

13.6.1.14.1. The housing shall be made up of homogeneous, vitreous porcelain of high mechanical and dielectric strength; glazing of porcelain shall be of uniform brown or dark brown colour with a smooth surface, arranged to shed away rainwater or condensed water particles (fog)

13.6.1.14.2. The bushings of the IVTS shall conform to latest edition of IS-2099.The hollow porcelain insulators shall conform to the latest edition of IS-5621

13.6.1.14.3. The insulators shall be cemented with Portland cement to the flanges resulting in high mechanical, tensile and breaking strength

13.6.1.14.4. The bushings shall have ample insulation, mechanical strength and rigidity for the condition under which they shall be used and shall be used and shall be designed to prevent accumulation of explosive gases and provide adequate oil circulation to remove the internal heat.

13.6.1.14.5. Cast metal and caps for the bushings shall be of high strength hot dip galvanized malleable iron. They shall have smooth surface to prevent discharge taking place between the metal parts and porcelain as a result of ionisation.

13.6.1.14.6. End shields should be provided for distribution of stresses.

13.6.1.14.7. Corona shields for bushings, if required, should be provided.

13.6.1.15. Insulating Oil:

The quantity of insulating oil for the filling and the complete specification of the insulating oil shall comply in all respects with the provisions of the latest edition of IS-335. The IVTs shall be supplied filled with **new oil.**

13.6.1.16. Prevention of Oil Leakage and Entry of Moisture:

The supplier shall ensure that the sealing of the IVT is properly achieved. In this connection, the arrangement provided by the supplier at various locations including the following ones shall be described, supported by sectional drawings

(a) Locations of emergence of primary & secondary terminals.

(b) Interface between porcelain housing and metal tank(s).

(c) Cover of the secondary terminal box.

(d) Sealing around oil level indicator.

13.6.1.16.1. Nuts and bolts or screws used for fixation of the interfacing porcelain bushings for taking out terminals shall be provided on flanges, cemented to the bushings and not on the porcelain.

13.6.1.16.2. For gasketed joints, wherever used, **nitrite butyl rubber/Neoprene gaskets shall be used**. The gasket shall be fitted in properly machined groove with adequate space for accommodating the gasket under compression.

13.6.1.17. Fittings and Accessories:

Fittings and accessories listed below shall be supplied with each IVT. Any fitting required essential other than those listed below shall also be supplied along with each IVT.

(a) Oil level gauge.

(b) Oil filling hole and cap.

(c) Pressure relieving device.

(d) Lifting lugs.

(e) Phase terminal connectors.

(f) Tank earthing pads/terminals with necessary nuts and bolts and washers for connecting to Purchaser’s strip.

(g) Name/Rating plate.

(h) H.R.C. fuse of Adequate rating

i) Bellow

13.6.1.18. Provisions

13.6.1.18.1. Oil Level Gauge:

An oil level gauge shall be provided to indicate the oil level in the IVT. This gauge shall be mounted in such a way that the oil level can be seen from the ground level.

13.6.1.18.2. Pressure Relieving Device:

Each IVT shall be provided with a pressure relieving device so as to protect bushing of the IVT even under unfavourable conditions.

13.6.1.18.3. Oil Drain Cock:

An oil drain cock along with a stop cock shall be provided in the bottom flange so as to permit taking of oil samples for testing, if required.

13.6.1.18.4. Earthing: Metal tank of each IVT shall be provided with two separate earthing terminals for bolted connection to be provided by the Purchaser for connection to station earth-mat.

13.6.1.18.5. Lifting Arrangement:

The IVT shall be provided with suitable lifting arrangement to lift the entire unit. The lifting arrangement shall be clearly shown in the general arrangement drawing.

Lifting arrangement [Lifting eye] shall be positioned in such a way so as to avoid any damage to the porcelain housing or the tanks during lifting for installation/transport. Necessary string guides shall be offered which shall be of removable type.

13.6.1.18.6. Name Plate:

The IVT shall be provided with non-corrosive legible name plate with the information specified in relevant standards, duly engraved/punched on it.

13.6.1.18.7. Gasket Joint:

The manufacturer shall furnish the type of gasket used or setting methods.

13.6.1.18.8. Terminal Connectors:

All the IVTs shall be provided with bimetallic solder less clamp type, rigid type terminal connectors, suitable for ACSR Conductor as per site requirement. Each terminal connector shall be of universal type, suitable for both horizontal and vertical connections to the transmission line conductors/station bus bar.

13.6.1.18.8.1. Terminal Connectors shall be manufactured and tested as per IS:5561.

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

13.6.1.18.8.3. No part of a clamp shall be less than 12mm. thick.

13.6.1.18.8.4. All ferrous parts shall be hot dip galvanized conforming to IS-2633

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

13.6.1.18.8.6. Connectors shall be designed to be corona free in accordance with the requirements, stipulated in IS-5561.

13.6.1.18.9. Secondary Wiring: The Secondary wiring shall be enclosed in conduits and shall be brought to a terminal block ready for external connections. The wiring shall be of adequate cross-section and not less than 2.5 sq.mm copper wire.

13.6.1.18.10. The supplier shall supply necessary hardwares, required for connection of phase side conductor to the line terminal and the grounding strip to the grounding terminal.

13.6.1.18.11. Necessary nuts and bolts for fixing the IVTS on the supporting structures shall be in tenderer's scope of supply.

13.6.2. GENERAL TECHNICAL REQUIREMENTS FOR 400KV, 220KV & 132KV CAPACITIVE VOLTAGE TRANSFORMER:

13.6.2.1. The CVT shall operate satisfactorily in system with high X/R ratio. (Tp=100 ms.).

13.6.2.2. The CVT transformer tanks along with top metallic shall be galvanized and painted to required shade.

13.6.2.3. Impregnation details along with tests and checks to ensure successful completion of impregnation cycle shall be furnished for purchaser's approval.

13.6.2.4. Bellows, if used to cater for expansion of insulating oil, shall be tested in accordance with relevant standards. The details shall be subject to the approval of the purchaser.

13.6.2.5. The CVT shall be capacitor voltage type with electromagnetic units and shall be suitable for carrier coupling.

13.6.2.6. All windings of voltage transformer secondaries shall be protected by HRC cartridge type fuses.. The secondary terminals of the CVTs shall be terminated to stud type non-disconnecting terminal blocks in the individual phase secondary boxes via the fuse. Fuse ratings shall be clearly mentioned.

13.6.2.7. CVTs shall be suitable for high frequency (HF) coupling, required for power line carrier communication. The carrier signal must be prevented from flowing into potential transformer (EMU) circuit by meant of a RF choke/reactor, suitable for effectively blocking the carrier signal over the entire carrier frequency range i.e. 40 to 500 KHZ. Details of the arrangement shall be furnished along with the bid. HF terminal of the CVT shall be brought out through a suitable bushing and shall be easily accessible for connection to the coupling devices of the carrier communication equipment, when utilized. The bushing shall be fully protected against rain and vermin so as to avoid the possibility of short circuits to earth. An earthing link with fastener shall be provided for HF terminal**. Test tap for Tan- delta and capacitance shall be provided.**

13.6.2.8. The electromagnetic unit, comprising compensating reactor, intermediate transformer and protective and damping devices should have a separate terminal box with all secondary terminals, brought out.

13.6.2.9. The accuracy of the windings (0.2/3P/3P) shall be maintained throughout the entire burden range preferably in the frequency range of 48 HZ to 51.5 HZ on all the three windings without any adjustment during operation. Preference will be given to such bidders who can offer for maintaining the above accuracy class in the frequency range i.e. 48 HZ to 51.5 HZ up to the above specified burden values.

13.6.2.10. Constructional Features:

13.6.2.10.1.The 400KV, 220KV & 132KV CVT shall be suitable for mounting on support structure of lattice type structures.

13.6.2.10.2.Access to secondary terminals shall be possible without any danger of access to high voltage circuit.

13.6.2.10.3.CVTs shall be hermetically sealed units.

13.6.2.10.4.**A protective surge Arrester/spark gap shall be provided to prevent break down 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. Surge arrester shall be provided in the secondary winding also.**

13.6.2.10.5.The CVT secondary terminals shall brought out into a weatherproof terminal box for ease of access. The terminal box shall have an IP rating of not less than IP 55. The terminal box shall be provided with a removable gland plate at the bottom and shall be suitable for accepting the required number of PVC insulated PVC sheathed, 10 core 2.5 mm^2 standard copper conductor cable.

13.6.2.10.6.All terminals shall be clearly marked to facilitate connection of secondary wiring.

13.6.2.10.7.Secondary fuses or MCBs shall be provided on or adjacent to each CVT, located such that they are accessible while the primary is live and shall be provided with labels indicating their function and their phase colours CVT secondary circuits shall be complete in themselves and shall be earthed at one point only. A separate earth link shall be provided for each secondary winding and shall be situated at the CVT. Primary earhing links should be provided.

13.6.2.10.7. To prevent ferro resonance, suitable damping devices shall provide for connection to the transformer secondaries.

13.6.2.10.8. CVTs shall meet the requirements, given in this section of the specification.

13.6.2.10.9. The creepage and flashover distances of the high voltage insulator shall be suitable for the outdoor service conditions, specified in the schedules.

13.6.2.10.10. The bidder in the offer is to state the suitable precautions/methods, adopted during design stage of the CVT to avoid the un-desirable effects due to ferro resonance phenomena.

13.6.2.10.11. It should be stated in the bid offer regarding the steps taken in the design stage for elimination/minimization of the influence of the transient response on the behaviour of high-speed relays.

13.6.2.10.12. It shall be ensured by the bidder in the offer that the connection of carrier, frequency coupling device across the CVT will not affect the designated accuracy class of the CVT windings.

13.6.2.10.13. The capacitor divider unit shall comply to IS: 9348/1979.

13.6.2.10.14. It shall also be complied in the offer through a calculation sheet, proving that the designated accuracy class of the CVT (both metering and protection) are not affected by extreme temperatures, to be encountered in service conditions (Max. ambient temperature 50º C and minimum -0º C).The terminal connectors should be suitable for ‘ACSR’ Conductor as per site requirement.

13.7. TESTS:

13.7.1 Type Tests:

The offered 33 KV& 132KV Inductive voltage transformer 400kV, 220kv, 132KV capacitive voltage transformer should have been subjected to the following type tests in a Government approved Test Laboratory. The bidder shall furnish four sets of type test reports along with the offer. These tests must not have been conducted earlier than five years from the date of opening of the bid. For any change in the design/type already type tested and to the design/type offered against this specification, the purchaser reserves the right to demand repetition of some or all type tests/special tests without any extra cost to AEGCL in the presence of purchaser's representative at the cost of the supplier.

For 33 KV, 132 KV IVT:

(a) Temperature rise test.

(b) Lightning Impulse Test.

(c) High Voltage power frequency wet withstand voltage tests.

(d) Determination of errors.

(e) IP-55 Test on secondary Terminal Box.

(f) RIV Test

(g) Creepage distance measurement test

N.B.: (i) The dielectric type tests should have been carried out on the **Same design and type of IVT.**

(ii) After the IVT was subjected to the dielectric tests, it should have been subjected to all routine tests as per relevant standards.

(iii) For Temperature Rise Test, the test must have been made with the appropriate rated burden, connected to each secondary winding.

For 400kV, 220kV & 132kV CVT.

Type Tests/Special Tests for 400kV, 220kV, 132kV CVT:

a) Lightning Impulse voltage test on complete CVT unit.

b) Power frequency over-voltage test on complete CVT unit.

c) Partial discharge test.

d) Radio interference voltage test.

e) Corona extinction voltage test.

f) Temperature rise test on complete CVT unit.

g) Ferro resonance test on the complete C.V.T. unit.

h) Transient response tests.

i) Determination of Temperature Co-efficient test.

j) High frequency capacitance and equivalent resistance measurement test (as per IEC-358)

k) Stray capacitance and stray conductance test (as per IEC-358).

l) Accuracy tests.

m) Thermal stability test.

n) Thermal Co-efficient test (as per IEC-358)

o) Fast transient test.

p) Seismic withstand test.

q) IP-55 test on secondary Terminal Box.

r) Magnetization and internal burden tests.

s) Effectiveness of sealing tests.

t) Mechanical Terminal load test on Bushing.

u) Dielectric loss angle test (Tan Delta Test).

v) Switching impulse withstand test

w) Critical impulse withstand voltage of insulator housing.

N.B: 1. The dielectric type tests should have been carried out on the same CVT.

2. After the CVT was subjected to the dielectric tests, it should have been subjected to all routine tests as per relevant standards.

3. The ratio errors, phase displacements before, during and after the temperature rise test on complete CVT unit should have been determined with stipulated burdens and the same should comply with the designated accuracy class for each winding of the CVT.

13.7.2 Routine Tests:

The following routine tests shall be conducted on each VT in the presence of Purchaser's representative for which no charges will be payable by AEGCL. No sampling is allowed.

(a) Verification of terminal markings.

(b) Power frequency withstand tests on primary windings/capacitor voltage divider for CVT

(c) Partial discharge measurement for 400kV, 220kV & 132kV CVT.

(d) Power frequency withstand tests on secondary windings/Low voltage terminal of the capacitor divider for 400kV, 220kV & 132kV CVT.

(e) Determination of errors on complete IVT/CVT.

(f) Measurement of Insulation resistance.

(g) Oil leakage test.

(h) Measurement of capacitance and dielectric dissipation factor before and after dielectric tests (as per IEC-358)

(j) Power frequency tests on electromagnetic unit for 400kV, 220kV & 132kV CVT.

(j) Any other test as per relevant national & international standards.

(k) Creepage distance measurement test.

N.B.: Determination of errors shall be performed after the other tests. The standard reference VT to be used during testing for determination of ratio error and phase angle error should of 0.05 accuracy class or better as per standard practice, presently adopted by AEGCL.

13.8. INSPECTION:

13.8.1. The Purchaser shall have access at all times to the works and all other places of manufacture, where the IVTs/CVTs are being manufactured and the supplier shall provide all facilities for unrestricted inspection of the supplier's works, raw materials, manufacturer of all the accessories and for conducting the necessary tests.

13.8.2. The Supplier shall keep the Purchaser informed in advance of the time of starting and of the progress of manufacture of equipment in its various stages so that arrangement could be made for inspection at the discretion of the Purchaser.

13.8.3. No material shall be dispatched from its manufacture unless the material has been satisfactorily inspected, tested and dispatch clearance issued. However, the Purchaser reserves the right to alter the despatch schedule attached to this Specification.

13.8.4. The acceptance of any quantity of equipment shall in no way relieve the supplier of his responsibility for meeting all the requirements of this Specification and shall not prevent subsequent rejection, if such equipments are found to be defective.

13.8.5. Clear 15 (Fifteen) days' notice shall be given to this office for deputing officer(s) for inspection. The Voltage Transformers shall be despatched only after the inspection is conducted by a representative of AEGCL and release order, issued from this office after approval of Routine Test Certificates. The shop routine test certificates in triplicate for all the Voltage Transformers along with the calibration certificates of all the meters and equipments to be used during testing (as per Annexure-B of the Specification) should be furnished along with the Inspection Offer. The Inspecting Officer will be authorised for inspection of the Voltage Transformers subject to the condition that the routine test certificates and calibration certificates of the testing equipments/meters will be found to be in order.

13.9. QUALITY ASSURANCE PLAN:

13.9.1. The Bidder shall invariably furnish following informations along with his offer.

(i) Statement giving list of important raw materials, names of sub-suppliers for the raw materials, list of standards, according to which the raw materials are tested, list of tests, normally carried out on raw materials in presence of Bidder's representative, copies of test certificates.

(ii) Information and copies of test certificates as in (i) above in respect of bought out items.

(iii) List of manufacturing facilities available.

(iv) Level of automation achieved and list of areas where manual processing exists.

(v) List of areas in manufacturing process where stage inspections are normally carried out for quality control and details of such tests and inspection.

(vi) Special features provided in the equipment to make it maintenance free.

(vii) List of testing equipments, meters and test plant limitation, if any, vis-à-vis the type, acceptance and routine tests, specified in the relevant standards. These limitations shall be very clearly brought out in the offer.

(viii) All the testing equipments, meters etc. should have been calibrated in a Government approved laboratory. The Bidder must submit the list of testing equipments and meters test as per the Technical Specification.

(ix) QAP shall include acceptance criteria against all parameters with relevant clause of standards

13.9.2. The Supplier shall within 30 days of placement of order submit the following information to the Purchaser.

(i) List of raw materials as well as bought out accessories and the names of the materials as well as bought out accessories and the name of Sub-suppliers selected from those, furnished along with the offer.

(ii) Type test certificates of the raw materials and bought out accessories.

(iii) Quality Assurance Plan (QAP) with hold points for the Purchaser's possible inspection. The QAP and hold points shall be discussed between the Purchaser and the Supplier before the QAP if finalised.

13.9.3. The Supplier shall submit the routine test certificates of bought out items and raw materials at the time of acceptance testing of the fully assembled equipment.

13.10. DOCUMENT:

The supplier shall furnish four sets of following drawings/documents along with his offer.

(a) General outline and assembly drawings of the Inductive Voltage Transformers/ Capacitive

Voltage Transformers.

(b) Sectional views showing:

i) General constructional features.

ii) Materials/gaskets/sealing used.

iii) The insulation of the winding arrangements, method of connection of primary/ secondary winding to the primary/secondary terminals etc.

(c) Schematic drawing.

(d) Rating & diagram plate as per relevant IEC/ISS

(e) Secondary Terminal Box.

(f) Assembly Sectional view of Primary terminal/capacitor voltage divider

(g) Assembly drawing for secondary terminal

(h) The detailed dimensional drawing of Porcelain Housing such as ID, OD, thickness and insulator details such as height, profile of petticoats, angle of inclination and gap between successive petticoats, total creepage distance etc.

(i) Sectional view of pressure release device.

(j) Drawing showing details of Oil level.

(k) All type test reports relating to the tests as specified in Clause-8.1 of the above.

(l) Ratio and phase angle error curves for IVTS/ CVTS

(m) Magnetization characteristic curves such as B-H curves and Sp. Loss vs. Flux density curves for core material, used for IVT & EMU unit of CVT.

(n) Sectional view of EMU unit of 220KV&132KV CVT.

(o) Schematic diagram showing the working of CVT in PLCC.

13.11. TEST REPORTS:

(i) Four copies of type test/special test reports shall be furnished to the Purchaser with the tender offer.

(ii) Copies of acceptance test reports and routine test reports shall be furnished to the Purchaser. One copy will be returned, duly certified by the Purchaser and only thereafter shall the materials be despatched.

(iii) All records of routine test reports shall be maintained by the supplier at his works for periodic inspection by the Purchaser.

(iv) All test reports of tests conducted during manufacture shall be maintained by the supplier. These shall be produced for verification as and when required for by the purchaser.

(v) The necessary galvanized flanges, bolts etc. for the base of the Inductive/Capacitive Voltage Transformers shall be supplied without any extra cost to the purchaser.

13.12 APPENDIX – I.

TECHNICAL REQUIREMENTS FOR 33kV, 132kV & 220kV INDUCTIVE VOLTAGE TRANSFORMERS & 132kV, 220kV, 400kV CAPACITIVE VOLTAGE TRANSFORMER.

Sl. No	Particulars	33kV IVT	132kV IVT	132kV CVT	400kV/220kV CVT
I	II	III	IV	V	VI
1	Type	Single phase, 50Hz, oil filled, self-cooled, Hermetically sealed, outdoor porcelain type.	Single phase, 50Hz, oil filled, self-cooled, Hermetically sealed, outdoor porcelain type.	Single phase, 50Hz, oil Filled, self-cooled, Hermetically sealed, Outdoor porcelain type.	Single phase, 50Hz, oil Filled, self-cooled, Hermetically sealed, Outdoor porcelain type.

2	Nominal system voltage.	33kV	132kV	132kV	400 kV/220kV
3	Highest system voltage.	36kV	145kV.	145kV	420kV/245kV
4	Frequency.	50Hz± 5%	50Hz± 5%	50Hz ± 5%	50Hz± 5%
5	System	Effectively	Effectively	Effectively	Effectively solidly earthed.
	earthing.	solidly earthed	solidly earthed	solidly earthed.	
6	Number of phases.	3 [single phase]	3 [single phase]	3 [single phase]	3 [single phase]
7	(i) Number of secondary windings. (ii) Purpose of windings.	3 [three] Protection & metering.	3 [three] Protection & metering.	3 [three] Protection & metering.	3 [three] Protection & metering.
8	Rated primary voltage.	33/1.732kV	132/1.732kV	132/1.732kV	400/1.732 kV 220/1.732 kV
9	Rated secondary voltage.	Winding-II &III- 110/1.732V (Protection) Winding-I- 110/1.732V (Metering)	Winding-II &III- 110/1.732V (Protection) Winding-I- 110/1.732V (Metering)	Winding-I- 110/1.732V Winding-II- 110/1.732V Winding-III- 110/1.732V	Winding-I- 110/1.732V Winding-II- 110/1.732V Winding-III- 110/1.732V
10	Ratio	33kV/1.732: 110V/1.732 110V/1.732	132kV/1.732: 110V/1.732 110V/1.732	132kV/1.732: 110V/1.732 110V/1.732	400kV/1.732: 110V/1.732, 110V/1.732 220kV/1.732: 110V/1.732 110V/1.732
11	Rated burden.	Winding-I(M)- 50VA Winding-II(P)- 50VA Winding-III(P)- 50VA	Winding-I(M)- 50VA Winding-II(P)- 50VA Winding-III(P)- 50VA	Winding-I (M)- 30VA Winding-II (P)- 30VA Winding-III(P)- 30VA	Winding-I (M)-30VA Winding-II (P)-30VA Winding-III(P)30VA
12	Accuracy class	0.2/3P/3P	0.2/3P/3P	0.2/3P/3P	0.2/3P/3P
13	Rated voltage factor at rated frequency.	1.2 continuous. 1.5 for 30second.	1.2 continuous. 1.5 for 30second.	1.2 continuous. 1.5 for 30second.	1.2 continuous. 1.5 for 30second.
14	Temperature rise at 1.2 times the rated primary voltage, rated frequency & rated burdens.	As per IEC- 186.	As per IEC-186.	As per IEC-186/61869	As per IEC-186/61869

15	Temperature rise at 1.5 times the rated primary voltage for 30 seconds, rated frequency & rated burden.	As per IEC- 186.	As per IEC-186.	As per IEC-186/61869	As per IEC-186/61869
16	One-minute power frequency dry/wet withstands test voltage for primary winding.	70kV[rms]	275kV[rms]	275kV[rms]	650kV[rms](400kV)/ 460kV[rms](220kV)
17					
18	1.2/50 micro second impulse withstand test voltage for primary winding	170kV[peak]	650kV[peak]	650kV[peak]	1425kV[peak] (400kV)/ 1050kV[peak] (220kV)
19 (i) (ii)	One-minute power frequency withstands test voltage for Secondary winding Between LV(HF) terminal & earth terminal	3kV[rms] -	3kV[rms] -	3kV[rms] 10kV[rms] for exposed terminals & 4kV[rms] for terminals, enclosed in a weatherproof box.	3kV[rms] 10kV[rms] for exposed terminals & 4kV[rms] for terminals, enclosed in a weatherproof box.
20	Class of insulation.	B	B	B	B
21	Material of the conductor of primary and secondary windings.	Copper.	Copper.	Copper for EMU	Copper for EMU
22	Fault level	31.5kA [rms] for 3 second.	40 kA [rms] for 3 second.	40 kA [rms] for 3 second.	50KA for 3 (220kV) / 63KA(400kV)[rms] for 3 second.

23	Minimum creepage distance.	1116mm	4495mm	4495 mm	13020(400kV)/7595(220kV) mm
24	Quality of oil.	EHV Grade As per IS-335.	EHV Grade As per IS-335.	EHV Grade As per IS- 335.	EHV Grade As per IS-335.
25	Radio interference voltage at 1.1 times maximum rated voltage at 1.0 MHZ.	-	500 micro volts.	500 micro volts.	500 micro volts.
26	Partial discharge level.	-	Less than 10 piccocoulombs.	Less than 10 Piccocoulombs.	Less than 10 piccocoulombs.
27	Seismic acceleration Horizontal – Vertical –	0.5g. 0.6g.	0.5g. 0.6g.	0.5g. 0.6g.	0.5g. 0.6g.
28	Accuracy class of standard V.T. to be used	0.05 or better.	0.05 or better.	0.05 or better.	0.05 or better.
	during testing towards determination of ratio errors and phase angle errors for metering windings.				
29.	Capacitance (Pf)	-	-	4400 + 10%, -5%	4400 (for 220kV), 8800 (for 400kV) + 10%, -5%

Note:

(i) For Station service bay equipments rated system voltage shall be 33kV and highest system voltage shall be 72.5kV.

CHAPTER 14: TECHNICAL SPECIFICATION OF CONTROL AND RELAY PANEL

14.1 TECHNICAL SPECIFICATIONS FOR CONTROL & RELAY PANELS:

a) This Section is intended to cover the design, manufacture, assembly, testing at manufacturer's works and erection, testing & commissioning of Indoor Relay and Control Panels.

b) The Control and Relay Panels required are for control and protection of the Power Transformers and Feeders according to requirements. The supply shall include all accessories, special tools, supporting steels, spare parts, drawings, relevant software, instruction manuals etc. The panels shall be supplied complete with all accessories as specified and completely assembled and all internal wiring completed.

c) The sub-stations shall have automation as per IEC 61850 protocol in Bay & Station level. The bidder has to supply the C&R panels to match the requirement of Sub-station Automation System (SAS) as specified in the subsequent chapter, **from the same manufacturer**.

d) **The manufacturer/supplier of Control and Relay Panels shall necessarily be an OEM (Original Equipment Manufacturer) of Numerical Protective Relays, Bay Control Units and Sub Station Automation System (SAS), having registered servicing unit in India.**

e) Design and fabrication of Control & Protection Panels for mounting the relay and relay assemblies along with all necessary accessories like switches, indicating lamps etc. and wiring up of the same to provide self contained and ready to use protection as per this specification.

f) Complete testing at manufacturer's works of the relays and protection schemes **including SAS** after mounting and fully wiring up in the Control & Protection Panels.

14.2 STANDARDS:

All equipment and all component parts supplied under this specification shall conform in all respects to the latest issue of relevant IEC and Indian Standard Specifications except where specified otherwise in this specification. Equipment meeting any other authoritative standards which ensure an equal or better quality may also be acceptable.

14.3 SERVICE CONDITIONS:

The plant and materials supplied shall be suitable for operation under the following climatic and other conditions as mentioned in chapter 2 of this Bid document:

14.4 TYPE TEST REPORTS.

14.4.1 Equipment, which have never been tested for critical performance, shall not be accepted. In such cases, a promise or agreement by a bidder to have the equipment tested after award of a contract is not acceptable.

14.4.2 All Bids must be accompanied by the full Type Test Certificates of equipment offered. Such type test certificates shall be acceptable only if:

i) Tests are conducted in KEMA/NABL accredited laboratory, *for GOOSE messaging etc as per relevant IEC 61850 Standards.*

ii) Inter-operability Tests are conducted in manufacturer's own laboratory. In this case (i) the laboratory must have ISO 9000 (or its equivalent) series certification; and (ii) tests have been witnessed by technically qualified representatives of earlier Indian clients of Central/State Transmission Utilities.

iii) The Validity of the Type Test Reports of CRP, Relays, BCUs and Energy Meters shall be as per CEA's "Guidelines for the Validity Period of Type Tests Conducted on Major Electrical Equipment in Power Transmission System", File No CEA-PS-14-80/1/2019-PSETD Division-Part (2).

14.5 TYPE OF PANEL

14.5.1 All simplex panels shall be swing type with front glass door with locking arrangement. The **Minimum number** of Panels shall be as per Table 1 below:

Table -1

	400kV	**220kV**	**132kV**	**33kV**
Feeder Panel	4 Nos if SWLR	2 Nos	2 Nos	1 No
Bus Coupler/Tie Breaker/Sectionalizer Panel	2 No	1 No	1 No	1 No
Reactor Panel	2 No			
Bus Bar Protection panel	4 Nos	2 Nos		
Transformer Panel	400/220/33kV AT	220/132kV AT	132/33kV PT	
	3Nos (Minimum)	2Nos (Minimum)	2 Nos (Minimum)	

14.5.2 Swing type Simplex Control and Relay Panels shall consist of vertical swing front panels with equipment mounted thereon and having front glass door. As there will be no rear door, manufacturer shall have to keep suitable swing angle, for maintenance & testing of equipment, circuitry inspection etc. Panel front shall have lockable glass door.

14.5.3 These panels shall be of the **Simplex type** with the following approximate dimensions:
i. Height: 2250mm + 15mm anti-vibration pad + 50 mm (base)
ii. Depth: 800mm to 1000 mm
iii. Width: 800 mm to 1000 mm
iv. Operating Height: 1800 mm

14.5.4 For 33kV feeder, panel shall be of simplex type and it should accommodate one 33kV feeder in
a single cubicle and one BCU will control single 33kV feeder.

14.6 CONSTRUCTIONAL FEATURES:

a) The panels shall be completely metal enclosed to ensure a dust, moisture and vermin proof atmosphere. The enclosure shall provide a degree of protection not less than IP 54 in accordance with IS-2147/IEC-60529.

b) Panels shall be rigid free standing and floor mounting type and comprise of structural frames enclosed completely with specially selected texture finished, cold rolled sheet steel of thickness not less than 3.15 mm for weight bearing members of the panels such as base frame, front sheet and door frames and not less than 2.0 mm for sides, door top and bottom portions. There shall be sufficient reinforcement to provide level surfaces, resistance to vibration and rigidity during transportation and installation.

c) All joints shall be made flush and all edges shall be bent at right angles and rounded. All structural members shall be bolted or welded together. Necessary arrangement shall be provided for bolting together the adjacent panels as well as for fastening them to the floor. The opening required for mounting the equipment shall be punched or cut and filed smooth.

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

e) Panels shall have additional rolled channel plinth at the bottom with smooth bearing surface. The panels shall be fixed on the embedded foundation channels with intervening layers of anti-vibration strips made of shock absorbing materials which shall be supplied by the contractor.

14.7 MOUNTING OF EQUIPMENTS:

a) All equipment on and in the panels shall be mounted and completely wired to the terminal blocks ready for external connection. All equipment on the front panels shall be mounted flush. Terminal markings shall be clearly visible.

b) Bay level intelligent electronic devices (IED) BPU for protection and control (BCU) and the Managed Ethernet Switch shall be housed in the C&R panels installed in the local control room.

14.8 INTERNAL WIRING:

a) Panels shall be supplied completely 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 located adjacent to each other all inter panel wiring and connections between the panels shall be furnished and wiring shall be carried out internally. These adjacent inter panel wiring shall be clearly indicated in the drawing furnished by the supplier.

b) Bay level intelligent electronic devices (IED) for protection, control (BCU) and the Managed Ethernet Switch shall be housed in the C&R panels installed in the local control room.
   i) All Circuits except instrument transformers **and incoming AC/DC Supply** circuits: 1.5 sq. mm. per lead.
   ii) Instrument transformers circuit: 2.5 sq. mm. per lead.

c) 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 panel running throughout the entire length of the panels.

d) Wire terminals shall be made with solder less clamping type of tinned copper lugs, which firmly grip the conductor and insulation. 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 wires and shall not fall off when the wire is disconnected from blocks.

e) Interconnections to adjacent panels shall be brought out to a separate set of terminals blocks located near the slots or holes meant for taking the interconnecting wires. Arrangement shall permit easy interconnection to adjacent panels at site and wires for this purpose shall be provided by the supplier looped and bunched properly inside the panel.

f) A laminated copy of total schematics is to be fixed on the inside of door.

14.9 TERMINAL BLOCKS:

a) All internal wiring to be connected to the external equipment shall terminate on terminal blocks, preferably vertically mounted on the side of each panel. Terminal blocks shall be of 1100 volts grade and have 10 amps continuous rating, moulded piece, complete with insulated barriers, stud type terminals, washers, nuts and lock nuts. Terminal block designs include a white fibre-marking strip with clear plastic/silicon chip on terminal covers. Marking on the terminal strips shall correspond to block and terminal number on the wiring diagram.

b) Terminal blocks for current transformer and voltage transformer secondary leads shall be provided with test links and isolating facilities. Current transformer secondary leads shall also be provided with short-circuiting and earthing facilities.

c) At least 20% spare terminals shall be provided on each panel and these terminals shall be uniformly distributed on all terminal blocks.

d) There shall be a minimum clearance of 250 mm between first row of terminal blocks and associated cable gland plates. Also, the clearance between two rows of terminal blocks shall be a minimum of 150 mm. A steel strip shall be connected between adjacent terminal block rows at 450-mm intervals for support of incoming cables.

14.10 PAINTING:

a) All Sheet steelwork shall be phosphated in accordance with IS 6005.

b) Oil grease, dirt and warp 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.

c) 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 2 (two) coats of ready mixed, stoving type zinc chromate primer. The first coat may be ‘flash dried’ while the second shall be stoved.

d) 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 completion of tests. Exterior Paint shall be texture finishing with RAL 7032 paint shade.

e) Each coat of primer and finishing paint shall be of a slightly different shade to enable inspection of the painting.

f) The inside of the panels shall be glossy white.

g) A small quantity of finishing shall be supplied minor touching up required at site after installation.

14.11 NAME PLATES AND MARKINGS:

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

b) All front mounted equipment shall be also 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. The nameplates shall be mounted directly by the side of the respective equipment and shall not be hidden by the equipment wiring.

c) Nameplates shall be made of non-rusting metal or 3 ply lamicord. Nameplates shall be black with white engraved lettering.

14.12 MISCELLANEOUS ACCESSORIES:

a) A 240 Volts, single-phase plug points shall be provided in the interior of each cubicle with ON-OFF switch for connection of headlamp.

b) Each panel shall be provided with a LED lighting fixtures for the interior illumination of the panel complete with all fittings, i.e. lamp, switch (controlled by panel door)

c) Each control panel shall be provided with necessary arrangements for receiving, distributing, isolating and fusing of D.C. and A.C. supplies of various control, AC & DC supervision, signalling, lighting and space heater circuits. MCBs of requisite capacity with fail indicators shall be used, HRC fuse is not acceptable. The main input A.C. and D.C. circuits will be protected with miniature circuit breakers.

d) Pistol Grip Trip Switch shall be provided.

14.13 EARTHING:

a) All panels shall be equipped with an earth bus securely fixed along with inside base of the panels. The materials and the sizes of the bus bar shall be at least **25X6 mm copper.** When several panels are mounted joining 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. Provisions shall be made for extending the earth bus bar to future adjoining panels on either side.

b) All metallic cases of equipment shall be connected to the earth bus by independent copper wires of size not less than 2.5 sq. mm. Earthing wire shall be connected on terminals with suitable clamp connectors and soldering shall not be permitted.

c) PT and CT secondary neutrals or common lead shall be earthed at one place only at the terminal blocks, where they enter the panels.

14.14 RECORDING METERS (ABT TRIVECTOR METERS):

14.14.1 General

a) All meters shall be housed in dust proof, moisture resistant, black finished cases and shall be suitable for tropical use. They shall be accurately adjusted and calibrated at works and shall have means of calibration, check and adjustment at site.

b) All these instruments and meters shall be flush mounted type and back connected, suitable for front panel mounting.

c) The ABT meters shall be SAMAST compatible as per specification given in subsequent chapter.

d) The meters should be compatible to IEC62052-11 and IEC62053-22, IEC62053-24, IS14697, IS15959.
e) The manufacturer shall provide Performance Certificate from CTU/STU of successful operation of minimum 3 years as on BID Opening.

14.15 RELAYS:

14.15.1 General

a) All relays shall conform to the requirements of IS 3231/ IEC 60255/ IEC 61000 or other relevant standards. The relay firmware/software shall be of the latest version.

b) All protective relays shall be numerical type and communication protocol shall be IEC 61850. Further, test levels of EMI as indicated IEC 61850 shall be applicable to these relays.

c) Two sets of relevant software (latest version) for relay configuration & setting, maintenance etc to be supplied to each station. The numeric relay and software shall be upgradable.

d) 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 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's coils and contacts, including spare contacts.
e) Relays shall be suitable for flush or semi-flush mounting with connectors from rear.

f) All draw out cases or plug in type modular cases will have proper testing facilities. The testing facilities provided on the relays shall be specifically stated in the bid. All protective relays shall be with proper online testing facilities without isolation from TB where inputs viz CT/ PT and DC are wired. All main relays shall be provided with test plug to test the relay online & required test handle may be invariably indicated. Necessary test plug shall be in the supplier's scope of supply and shall be supplied loose. Unless otherwise specified all auxiliary relays and timers shall be supplied either in non-draw out cases or plug in type modular cases.

g) All A.C. relays shall be suitable for operation at 50 Hz. A.C. Voltage operated relays shall be suitable for 110 volts VT secondary and current operated relays for 1Amp. CT secondary. DC auxiliary relays and timers shall be designed for 110 volts/ 220 volts DC and shall operate satisfactorily between 70% and 110% of rated voltage. Voltage operated relays shall have adequate thermal capacity for continuous operation.

h) All Protective relays, auxiliary relays and timers except the lockout relays and interlocking relays shall be provided with self-reset type contacts. All protective relays, trip relays and timers shall be provided with externally/ electrically reset positive action operation indicators provided with proper inscription. All protective relays which do not have built-in hand reset operation indicators shall have additional auxiliary relays with operating indicators for this purpose. Similar separate operating indicators (auxiliary relays) shall also be provided in the trip circuits of protections located outside the board such as Buchholz relays, temperature protection etc.

i) No control relays that shall trip the circuit breaker when the relays are de-energized shall be employed in the circuits.

j) All relays shall withstand a test voltage of 2.5 kV, 50 Hz rms. voltage for one second. In case of static relays, the Clause 14.28.1.l shall be applicable.

k) Auxiliary seal-in unit provided in the protective relays shall preferably be of shunt reinforcement type. If series relays are used the following shall be strictly ensured:

(i) The operating time of the series seal-in unit shall be sufficiently shorter than that of the trip coil relay in series with which it operates to ensure definite operation of the flag indicator of the relay.
(ii) Seal - in unit shall obtain adequate current for operation when one or more relays operate simultaneously.
(iii) Impedance of the seal-in unit shall be small enough to permit satisfactory operation of the trip coil on trip relays when D.C. supply is minimum.
(iv) 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.

(v)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).

(vi)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.

(vii)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).

l) Whenever solid state auxiliary relays are used the following requirements shall be met with:

i)The printed circuit cards shall be of fibre glass type and the contact shall be gold plated. All connectors with the connector pegs shall be through wire wrapping. All solder Joints on the printed circuit boards shall be encapsulated or covered with varnish.

ii) The components shall be loaded by less than half of their rated values. The resistor shall be of carbon composition or metal oxide type and the capacitors shall be plastic film or tantalum type. Stringent measures including shielding of long internal wiring should be taken to make relays immune to voltage spikes. Relays must withstand 5kW, 1x150 microsecond, O.5 Joule source energy impulse test or 1.5 MHz damp oscillations with initial value of 2.5 kV decaying to half the initial value in 6 microseconds with internal source impedance of 150 ohms.

iii) The supplier shall ensure that the terminals of the contacts of the relays are readily brought out for connectors as required in the final approved scheme.

iv) DC /DC converter shall be provided in the solid state protective relays wherever necessary in order to provide a stable auxiliary supply for relay operation. Provision of DC cell in the protective relays as relievable stand-by power supplies will however not be acceptable.

m) Provision shall be made for easy isolation of trip circuits of each relay for the purpose of testing and maintenance.

n) All Spare pair of contacts of all IEDs and Alarm Relays shall be wired to Terminal Blocks exclusively for Employer’s use.

o) All relays and their drawings shall have phase indications as R-Red, Y-Yellow, B-Blue.

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

14.15.2 General Specification of Numerical Relays

a) Numerical Relays shall be provided for the following applications:

i) Distance Protection (Main I & Main II) of different make and model for 400KV and 220 kV lines.
ii) Distance protection for 132 kV lines.
iii) Back up directional over current and earth fault relays for 132 kV Lines.
iv) Back up non directional over current (3 O/C) and earth fault relays for 33kV lines
v) Bus Bar Protection.
vi) Integrated Numerical Transformer Differential Protection as Main –I & Main-II of different make **and model** with non-directional overcurrent and earth fault function with high set units for power and autotransformers/ reactors.
vii) Reactor Protection.

viii) *Line Differential Protection*

(viii) 3 winding transformer protection relay for Main-1 & Main-2 shall be provided for all the transformers under the scope of this bid

b) All Numerical Relays should have following minimum features.

i) Relays shall be communicable on IEC61850 protocol without any protocol converter. Certificate from KEMA confirming interoperability, Goose messaging &

publishing as per IEC61850 standard shall be submitted along with the tender. The relay shall have suitable communication facility for future connectivity to SCADA.

ii) Relays shall have one no. front RJ45 or USB port (for RS 232 port Converter to USB shall be supplied for each substation along with spare) for Local Relay Parameterization and Two nos. rear FO port for connectivity to SAS over IEC61850 protocol.

iii) The relay shall have self-communication port monitoring feature and failure shall generate alarm.

iv) The relay shall have sufficient battery back up to keep the internal clock running for at least 2 years in absence of auxiliary supply. The capacitor discharging power is not sufficient and won't be accepted. Proper battery back must be provided.

v) Should have minimum 12 configurable LEDs for 132kV and above voltage class.

vi) Should have minimum **24 Binary Inputs and 32 Binary Outputs**. Moreover, the relays shall have minimum 30% BI & BO as spare after fulfilment of scheme requirement.

vi) All BI/BOs shall be site configurable

vii) Shall have front minimum 3 lines LCD display with Alpha numeric keypad.

viii) Numerical relays are to be provided with built in Event / Disturbance / Fault Recorder features.

ix) The bidder shall bring out in the bid that the Numerical relays providing different protection features / application in a single unit if any one of the application/ features goes out of service the other feature/application (s) will remain un-effected.

x) The relays shall be site configurable (Including logic development**)**

xi) Configured features & set values shall be in non-volatile memory

xii) Must have real time clock for time stamping of events/ disturbances with time synchronization inputs (GPRS etc.). Time synchronisation through SNTP compatible.

xiii) The major component cards shall be hot swappable and front or rear loading.

xiv) The relays should have self-diagnostic features identifying area of fault or failure of a particular component or card.

xv) Shall have in built Circuit Breaker Failure protection based on undercurrent detection and/or circuit breaker auxiliary contact status. Provision shall be given to initiate the breaker fail logic using a digital input from external protection devices.

xvi) Relay shall have inbuilt PRP ports.

xvii) Relays shall have redundant communication channels for Protection Communication.

c) Hardware based measurement shall not be acceptable.

d) The relay should have high immunity to electrical and electromagnetic interference.

e) The same relay shall be provided with both 1A CT inputs and shall be site selectable.

f) It shall be possible to energise the relay from either AC or DC auxiliary supply. Auxiliary dc supply shall be suitable for both 110 and 220 Volt and shall be site selectable.

g) Be capable of performing basic instrumentation functions and displaying various instantaneous parameters like Voltage, current, active power, reactive power, phase sequence etc. in primary values. Additionally, all sequence current and voltage values shall be displayed on-line. Also the direction of power flow shall be displayed.

h) Extensive disturbance recording facility shall be available for at least up to 10 seconds to capture maximum possible information. Necessary software shall be provided for retrieving and analysing the records.

i) Facility for developing customised logic schemes inside the relay based on Boolean logic gates and timers should be available. Facility for renaming the menu texts as required by operating staff at site should be provided.

j) Must have additional feature of local breaker back up protection

i) The relay shall have built in Circuit Breaker Supervision Functions.

ii) The relay shall be able to detect any discrepancy found between NO & NC contacts of breaker.

iii) The relay shall monitor number of breaker trip operations.
iv) The relay shall also monitor the breaker operating time.

k) The relays shall have the following tools for fault diagnostics:

i) Fault record (shall be function of IED): – The relay shall have the facility to store fault records with information on cause of trip, date, time, trip values of electrical parameters.
ii) Event record (shall be function of IED): – The relay shall have the facility to store time stamped event records with 1ms resolution.
iii) Disturbance records (shall be function of IED): – The relay shall have capacity to store disturbance records of at least 10 sec. duration and sampling rate per cycle shall be more than 15.

l) It shall be possible to preserve stored information in the event of an auxiliary supply failure with the help of a battery backup.

m) The relay settings shall be provided with password protection.

n) It shall be possible to change the relay setting from the front panel using the key pads/ Work station of SAS and Laptop.

o) The relay shall have comprehensive self-diagnostic feature. This feature shall continuously monitor the healthiness of all the hardware and software elements of the relay. Any failure detected shall be annunciated through an output watchdog contact. The fault diagnosis information shall be displayed on the LCD. These records shall also be retrieved from local as well as remote terminal through the communication port.

p) The Numerical Relays shall be provided with 2 sets of common support software (latest version) compatible with latest version of Windows OS which will allow easy settings of relays in addition to uploading of event, fault, disturbance records, and measurements to Station HMI/ DR Work Station. The relay settings shall also be changed from local or remote using the same software**.**

q) In case of line protection and transformer/reactor protection, the features like fault recorder, disturbance recorder and event logging function as available (including if available as optional feature) in these relays shall be supplied and activated **at no extra cost to the owner**.

r) The manufacturer shall have to provide up-graded support software if any within 10 years span**.**

14.16 Transmission Line Protection :

14.16.1 Line Differential Protection Relay (If Applicable)

Main I and Main II Line Differential Protection shall be of **different make and model.**

The relay shall have all the features as per Distance protection relay over and above following features

1. It shall be working on phase segregated Current Differential protection principle.
2. It shall have multiple slope characteristic (preferably) to have stability against CT saturation and heavy through faults as well as sensitivity for internal faults.
3. It shall measure Differential as well as restrain current continuously and shall display the same as measurement.
5. It shall communicate to remote end through IEEE C37.94 format.
6. It shall have redundant communication channels for protection communication.
7. It shall communicate analogue as well as digital signals to remote end.
8. It shall have various communication options for remote communication i.e. mono-mode / multi-mode for direct communication / communication through multiplexer.
9. It shall have Line charging current compensation feature for better sensitivity.

10. Distance protection function can be utilized as independent or as back up of Differential protection in case of failure of remote communication. . It shall have a full scheme distance protection scheme to provide independent protection in parallel with the differential scheme in case of a communication channel failure for the differential scheme. The distance protection then provide protection for the entire line including the remote end back up capability either in case of a communications failure or via use of an independent communication channel to provide a fully redundant scheme of protection (that is a second main protection scheme). Eight channels for intertrip and other binary signals are available in the communication between the IEDs. The auto-reclose for single-, two- and/or three phase reclosing includes priority circuits for multi-breaker arrangements. It co-operates with the synchronism check.

11. It shall communicate time coordinated current signals for remote communication to execute Line differential protection algorithm accurately. Time synchronization through GPS shall also be possible.

12. It shall monitor individual communication links continuously and switchover to standby link after preset time in case of failure of one link.

13. It shall supervise individual telegrams.

14. It shall detect reflected telegrams.

15. It shall detect change in communication It shall measure delay time for remote end along with dynamic compensation of the same in differential protection algorithm.

17. It shall also supervise maximum permissible delay time.

18. It shall generate alarm for heavily disturbed communication link. Technical Parameters

    A. Line Differential Protection setting:

    1. Minimum operating current - 20 to 200% of In

    2. Slope (Single/dual) - 10 to 100%

    3. End section (Single/dual) - 20 to1000% of In

    4. Highset operating current - 100 to 5000% of In

    5. 2 nd Harmonic blocking - 5 to100 %

    6. Typical operating time - 25 ms

    7. Operating time for high set - 15 to 20 ms

    8. Charging current comp. – Selectable

    B. Remote communication:

    9. Analogue signal transfer – Minimum 3 Nos.

10. Binary signal transfer - Minimum 8 Nos
11. Remote Communication module

    Dual modules suitable for

    a) 1300 nm - multi-mode

    OR

    b) 1300 / 1550 nm – mono-mode

    (finalized during detailed engineering)
12. Synchronization mode - GPS / Echo (finalized during detailed engineering)
13. Time delay alarm - 5 to 500 ms, step 5 ms (for communication fail)
14. Time delay - 5 to 500 ms, step 5 ms (for switching to redundant channel)
15. Asymmetric delay - - 20 to +20 ms, step 1 ms (When echo mode is used)
16. Max. Transmission delay – 0 to 40 ms, step 1 ms

14.16.2 Distance Protection Relay

i) The distance protection relay shall be fully numerical using microprocessors and be based on a non-switched scheme.

ii) The distance protection relay shall have at least three completely independent non switched forward directional zones, one extended zone and a reverse directional zone protection.

iii) Have non-switched measurement, which implies processing of six possible fault loops (six –loop measurement).

iv) The protection algorithm shall utilize fault voltages and currents, as well as the superimposed voltages and currents to arrive at a secure trip decision in the shortest possible time with reliability, selectivity and full sensitivity to all types of faults online.

v) Have polygonal characteristics with independently adjustable reactive and resistive reaches for maximum selectivity and maximum fault resistance coverage. The zones shall have independent settable earth fault compensation factors to cater to adjacent lines with different zero sequence to positive sequence ratios.

vi) Selection shall be so that the first zone of the relay can be set to about 80% - 85% of the protected line without any risk of non-selective tripping.

ix) The second and third zone elements shall provide backup protection in the event of the carrier protection or the first zone element failing to clear the fault, zone-2 shall cover full protected section plus 50 % of the next section, zone-3 shall normally cover the two adjacent sections completely. The zones must have independent time settings.

x) Shall have resetting time of less than 55 milli-seconds (including the resetting time of trip relays)

xi) All the zones shall have setting such that they can detect the fault online from minimum 0.3 km to 500 km.

xii) The maximum fault current could be as high as 63kA but the minimum fault current could be as low as 20% of rated current. The starting and measuring relays characteristics should be satisfactory under these extreme varying conditions.

xiii) The relay shall use the memory voltage for proper directional discrimination at close in 3 phase fault which shall be based on positive sequence voltages. The directional discrimination and phase selection based on negative sequence measurement techniques is not acceptable.

xiv) Have adequate number of forward zones (minimum three) and a reverse zone. The zone reach setting ranges shall be sufficient to cover line lengths appropriate to each zone. Carrier aided scheme options such as permissive under reach, overreach, & blocking and non-carrier aided schemes of zone 1 extension and Loss of load accelerated tripping schemes shall be available as standard. Weak in feed logic and current reversal guard also shall be provided.

xv) In case the carrier channel fails, one out of the non-carrier-based schemes cited above should come into operation automatically to ensure high speed and simultaneous opening of breakers at both ends of the line.

xvi) Shall have suitable number of potential free contacts for Carrier Aided Tripping, Auto Reclosing, CB Failure, Disturbance/Fault recorder and Data Acquisition System.

xvii) Have a maximum operating time up to trip impulse to circuit breaker (complete protection time including applicable carrier and trip relay time) for SIR 0.01-4: as 40ms at the nearest end and 60ms at the other end of line & for SIR 4-15: as 45ms at the nearest end and 65ms at the other end of line with carrier transmission time taken as 20ms. Isochronic curves shall be provided in support of operating times.

xviii) Shall have an independent Directional Earth Fault (DEF) protection element to detect highly resistive faults as a built in feature. This element shall have an inverse time/definite time characteristic.

xix) Has logic to detect loss of single /two-phase voltage input as well as three-phase voltage loss during energisation and normal load conditions. The voltage circuit monitoring logic in addition to blocking the distance protection element, enable an emergency over current element to provide a standby protection to the feeder until the re-appearance of voltage signal.

xx) The VT fuse failure function shall function properly irrespective of the loading on the line. In other words, the function shall not be inhibited during operation of line under very low load conditions.

xxi) Have necessary logic to take care of switch-on-to-fault condition. Energisation of transformers at remote line ends and the accompanying inrush current shall not cause any instability to the operation of relay.

xxii) Have power swing blocking and Out of Step protection feature, with facilities for fast detection of power swing selective blocking of zones settable unblocking criteria for earth faults, phase faults and three phase faults. It shall be on the principle of measurement of the rate of impedance vector change and monitoring of the vector path. It should have the Earth fault detection feature, which shall override power swing blocking and allow the relay to operate for trip as per zone detection. The relay shall be blocked for the set time for the first PS sensed and remain unblocked for the set time for the successive PS.

xxiii) Be suitable for single pole or three pole tripping. However, relays offered for 132 kV lines provided with mechanically ganged circuit breakers, single pole tripping need not to be provided.

xxiv) Be suitable for both bus PT or Line PT/ CVT supply.

xxv) Shall have in built Trip circuit supervision facility to monitor both pre- and post close supervision facilities. An alarm shall be generated.

xxvi) Shall have in built broken conductor detection by way of level detector or negative sequence measurement.

xxvii) Shall have df/dt functions.

xxviii) Shall have multistage under frequency setting options.

xxix) The sensitivity of the logic shall not be affected during operation under low load.

xxx) Shall have a fault locator with an accuracy of ±3%. The display should be in kilometres and preferably in percentage impedance too. The fault locator should have built in mutual compensation for parallel circuit.

xxxi) Have mutual zero sequence compensation factor setting. The relay shall have facility to select different group settings to cater for mutual coupling on account of multi circuit line conditions. The minimum no. of group should be four.

xxxii Have at least 24 no of programmable BI and 32 no of programmable BO contact to cater for DR/SER carrier aided tripping auto re-closing etc.

xxxii) The distance relays shall have a built-in auto-reclose function with facilities for single pole / three pole / single and three pole tripping. It shall be possible to trigger the A/R function from an external protection**.** A voltage check function which can be programmed for deadline charging/dead bus charging / check synchronising shall be included. However, the relay shall support independent A/R scheme.

xxxiii) Shall have additional features to provide under/ over voltage protection.

xxxiv) Shall have additional features to provide under frequency protection

xxxv) Shall have memory circuits with defined characteristics in all three phases to ensure correct operation during close-up 3 phase faults and other adverse conditions and shall operate instantaneously when circuit breaker is closed to zero-volt 3 phase fault.

xxxvi) The protective relays shall be suitable for use with capacitor voltage transformers having non electronic damping and transient response as per IEC.

xxxvii) Shall have a continuous current rating of two times of rated current. The voltage circuit shall be capable of operation at 1.2 times rated voltage. The relay shall be also capable of carrying a high short time current of 70 times rated current without damage for a period of 1 sec.

xxxviii) Must have a current reversal guard feature.

xxxix) Shall have Stub Protection function with current setting minimum range of 1 to 3 pu with definite time delay setting, minimum range of 0 to 100 msec

xl) Have feature of load encroachment blinder to safeguard the protection trip during heavy line loading condition.

14.16.3 Integrated Numerical Transformer Protection Relay

a) GENERAL REQUIREMENTS:

i) Shall be stable during magnetising inrush and over fluxing conditions. Stabilization under inrush conditions shall be based on the presence of second harmonic components in the differential currents.

ii) Shall have saturation discriminator as an additional safeguard for stability under through fault conditions.

iii) Shall have zero sequence current filtering, which may be deactivated separately for each winding, for special applications.

iv) Shall have software to take care of the angle & ratio correction of CT inputs.

v) Shall have all output relays suitable for both signals and trip duties

b) FUNCTIONAL DESCRIPTIONS:

The integrated Numerical Transformer Protection Scheme shall have following functional qualities:

1) Differential protection:

i) The relay shall be biased differential protection with triple slope tripping characteristics with faulty phase identification / indication. The range for the differential pick-up shall be from 0.1 to 2.5 p.u. Its operating time shall not exceed 30 ms at 5 times rated current.
ii) The relay shall have two adjustable bias slopes from 20 % to 150 % and slope from 40% to 150 %, to provide maximum sensitivity for internal faults with high stability for through faults
iii) The relay shall have an unrestrained high set element to back up the biased differential function and the setting range for it shall have a minimum setting of 5pu and a maximum setting of 30pu.
iv) The relay shall have the second harmonic restraint feature for stability under transformer inrush condition. The setting shall be 15-25%.
v) Further, the fifth harmonic blocking for stability under transient over fluxing condition shall be provided.
vi) Have suitable non-linear resistors along with stabilizing resistor for CT Circuit to limit peak voltage during in-zone faults in case of high impedance type.
vii) Have a fault recording feature to record graphic form of instantaneous values of following analogue channels during faults and disturbances for the pre fault and post fault period: **Current in all three windings in nine analogue channels plus three analogue channels for Backup protection in case of 400kV class/ 220kV Class (In case of loaded tertiary) or 9 analogue channels for lower voltage transformers and voltage in three channel.**
viii) The Disturbance recorder function built in the Differential Protection IED shall have the facility to record the following external digital channel signals associated with transformer which shall be wired to differential relay apart from the digital signals pertaining to differential relay:
   a) REF Protection Operated
   b) HV Breaker Status (Main &Tie/Transfer both separately)
   c) IV/LV Breaker status (Main & Tie/Transfer both separately)
   d) Bucholz/OLTC/OTI/WTI alarm
   e) Bucholz/ PRD/ SPR Trip
   f) Group-A/ Group-B lockout relay trip

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

ix) The Relay shall have Reverse Power Protection feature.
x) The Differential Relay shall be designed for the protection & control of 3 winding Transformer

2) Restricted Earth fault Protection:

The scheme shall have in-built restricted earth Fault (REF) for both the windings. The REF function shall be configurable to Auto Transformer also. This function should be provided to maximise the sensitivity of the protection of earth faults. **Both the Differential relay shall have inherent high impedence REF element**. The REF function should be able to share Current Transformers with the biased differential function. As in traditional REF protection s, the function should respond only to the fundamental frequency component of th e currents. For star/star transformer, both the windings shall be protected through REF, as such relay shall have sufficient analogue channels to accommodate the s ame.

3) Over fluxing Protection:

i) The over fluxing protection shall be built in the relay. By pairs of V/f and t, it shall be possible to plot the over fluxing characteristics so that accurate adaptation of the power transformer data is ensured.
ii) In addition, the relay should have a definite time element for alarm.
iii) The relay should monitor all the three phase voltages for calculation of V/f and should take the highest voltage for V/f calculation.

4) Thermal Overload Protection:

i) Shall have two stages of thermal overload protection for alarm and trip condition with continuously adjustable setting range of 100-400% of rated current and time constant setting range of 1.0 to 10.00sec continuously.
ii) Shall be single pole type.
iii) Shall have a drop off/pick up ratio greater than 95%.
iv) Shall have separately adjustable time delay relays for alarm having a setting range of 1to 10 seconds continuously.

5) Over Current and Earth fault protection:

i) The relay shall have three stages of definite time **Directional** over current protection as backup operating with separate measuring systems for the evaluation of the three phase currents, the negative sequence current and the residual current.
ii) In addition, the relay shall have three stages of Inverse time **Directional** over current protection operating based on one measuring system each for the three phase currents, the negative sequence current and the residual current.
iii) Shall have additional features to provide under/ over voltage protection.
iv) Shall have additional features to provide under frequency protection.
v) The Earth fault relay shall have directional IDMT characteristic with a definitive minimum time of 3.0 seconds at 10 times setting and have a variable setting range of 20-80% of rated current. (with selectable IEC Curves).
vi) The Earth fault relay shall have low transient, overreach high set instantaneous unit of continuously variable setting range 200-800 % of rated current.

6) Transformer Neutral Current relay (for 400 KV class transformer only) 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. (with selectable IEC Curves)

14.16.4 Over Current and Earth Fault Relays

These relays shall be of numeric, single/multi pole, directional /non-directional type with high set element as specified. These relays shall have the following features/characteristics:

(i) IDMT characteristic with definite minimum time of 3 second at 10 times setting.

(ii) Other operating curves such as inverse, very inverse shall be selectable

(iii) Adjustable setting range of 50-200 % and 20-80% of rated current for over current and earth fault relays respectively.

(iv) The directional relays shall have a Maximum torque angle of 45° current leading for directional over current unit & 30 lag for directional earth fault. Other MTAs should be settable

(v) Voltage polarizing coil: 63.5 or 110volt

(vi) Must have faulty phase, type of fault identification

(vii) The directional relays shall have over voltage/ under voltage & under frequency built in protection

(viii) The relay shall have blocking scheme on Reverse Power Flow.

(ix) Include LED indicators.

14.16.5 Reactor Protection

14.16.5.1 REACTOR DIFFERENTIAL PROTECTION RELAY Shall

(i). Be triple pole type.

(ii). Have operation time less than 25 milli-seconds at 5 times setting

(iii). Be tuned to system frequency.

(iv). Have an operating current sensitivity of at least 10% of nominal current

(v). Have current setting range of 10 to 40% of 1 Amp. or a suitable voltage setting range

(vi). Be high impedance / biased differential type.

(vii). Have suitable non-linear resistors along with stabilizing resistor for CT Circuit to limit peak voltage during in-zone faults in case of high impedance type.

(viii). Be stable for all external faults.

14.16.5.2 REACTOR RESTRICTED EARTH FAULT PROTECTION RELAY shall

(i). Be single pole type.

(ii). Be of current/voltage operated high impedance type.

(iii). Have a current setting of 05-40% of 1 Amp. / have a suitable voltage setting range

(iv). Be tuned to system frequency

(v). Have a suitable non-linear resistor to limit the peak voltage to 1000 Volts.

14.16.5.3 REACTOR BACK UP IMPEDANCE PROTECTION RELAY shall

(i). Be triple pole type, with faulty phase identification/ indication.

(ii). Be single step polarized 'mho' distance/ impedance relay suitable for measuring phase to ground and phase to phase faults

(iii). Have adequate ohmic setting range to cover at least 60% of the impedance of the reactor and shall be continuously variable

(iv). Have an adjustable characteristic angle of 30-80 degree

(v). Have a definite time delay relay with a continuously adjustable setting range of 0.2-2.0 seconds

(vi). Include VT failure relay which shall block the tripping during VT fuse failure condition.

(vii). Have Back Up over Current and Earth fault protection as built in function.

14.16.6 Circuit Breaker Protection

a) **LOCAL BREAKER BACK-UP PROTECTION SCHEME** shall

(i). Be triple pole type.

(ii). Have an operating time of less than 15 milli seconds

(iii). Have a resetting time of less than 15 milli seconds

(iv). Have three over current elements

(v). Be arranged to get individual initiation from the corresponding phase of main protections of line for each over current element. However, common three phase initiation is acceptable for other protections and transformer /reactor equipment protections

(vi). Have a setting range of 10-80% of rated current

(vii). Have a continuous thermal withstand two times rated current irrespective of the setting

(viii). Have a timer with continuously adjustable setting range of 0.1-1 seconds

(ix). Have necessary auxiliary relays to make a comprehensive Scheme

(x). Shall have re-trip feature for tripping its own CB after initiation with a set time delay.

(xi). Be acceptable as Built-in protection function of distributed bus bar protection scheme only; however in that case separate LBB relay shall be provided for tie bays.

b) **NUMERICAL AUTO RECLOSING FUNCTION** (where specified) shall be an in built feature of Main-I and Main-II protection relay. The Auto Reclose shall

(i). Have single phase and three phase reclosing facilities.

(ii). Have a continuously variable single-phase dead time range of 0.1-2 Seconds

(iii). Have a continuously variable three phase dead time range of 0.1-2 Seconds

(iv). Have a continuously variable reclaim time range of 5-300 seconds

(v). Incorporate a four-position selector switch/ from which single phase/three phase/single and three phase auto-reclosure and non-auto reclosure mode can be selected. Alternatively, the mode of auto reclosing can be selected through HMI of the relay or BCU & SAS.

(vi). Have facilities for selecting check synchronizing or dead line charging features. It shall be possible at any time to change the required feature by reconnection of links.

(vii). Be of single shot type

(viii). Have priority circuit to closing of both circuit breakers in case one and half breaker arrangements to allow sequential closing of breakers

(ix). Include check synchronizing relay which shall

- Have a time setting continuously variable between 0.5-5 seconds with a facility of additional 10 seconds
- Have a response time within 200 milli seconds with the timer disconnected.
- Have a phase angle setting not exceeding 35 degree
- Have a voltage difference setting not exceeding 10%
- Include deadline charging relay, which shall
- Have two sets of relays and each set shall be able to monitor the three-phase voltage where one set shall be connected to the line CVTs with a fixed setting of 20% of rated voltage and the other set shall be connected to the bus CVTs with a fixed setting of 80% of rated voltage.

- Incorporate necessary auxiliary relays and timers to give comprehensive scheme.

Auto Reclose function shall be an in-built feature of the BCU and the signal exchange for auto-reclose function from BCU to main relays and vice versa shall be achieved through hard wiring and GOOSE parallelly.

14.17 Bus Bar Protection Relay

a) These relays shall also be of numeric type.

b) Redundant (1+1) numerical low impedance biased differential Bus Bar protection scheme for each bus system (Bus1 +Bus2) for 400kV shall be provided. The scheme shall be engineered so as to ensure that operation of any one out of two schemes connected to main faulty bus shall result in tripping of the same.

c) Single bus bar protection scheme shall be provided for each main bus **(Main I/Main II)** and transfer bus (as applicable) for 220KV and **132kV** voltage level.

d) Each Bus Bar protection scheme shall

i) Have maximum operating time up to trip impulse to trip relay for all types of faults of 25 milli seconds at 5 times setting value.

ii) Operate selectively for each bus bar

iii) Give hundred percent security up to 63 KA for fault level for 400 KV , 50kA for 220 KV and 40 KA for 132 KV

iv) Incorporate continuous supervision for CT secondary against any possible open circuit and if it occurs, shall render the relevant zone of protection inoperative and initiate an alarm

v) Not give false operation during normal load flow in bus bars

vi) Incorporate clear zone indication

e) It shall have End fault Protection & LBB function

f). Be of phase segregated and triple pole type. The bus bar scheme may be Centralized or De-Centralized
type and it must accommodate all future bays as per Project along with tripping relay s.

g) Provide independent zones of protection (including transfer bus if any). If the bus section is provided, then each side of bus section shall have separate set of bus bar protection schemes

h) Include individual high speed electrically reset tripping relays for each feeder. However, in case of distributed Bus bar protection, individual trip relay shall not be required if bay unit is having trip duty contacts for breaker tripping.

i) Be transient free in operation

j) Include continuous D.C. supplies supervision

k) Not cause tripping for the differential current below the load current of heaviest loaded feeder. Contractor shall submit application check for the same.

l) Shall include necessary C.T. switching relays wherever C.T. switching is involved and have 'CT' selection incomplete alarm

m) Include protection 'IN/OUT' switch for each zone

n) Shall include trip relays, CT switching relays (if applicable) , auxiliary CTs (if applicable) as well as additional power supply modules, input modules etc. as may be required to provide a Bus bar protection scheme for the complete bus arrangement i.e. for all the bays or breakers including future bays as per the Single line diagram for new substations. However, for extension of bus bar protection scheme in existing substations, scope shall be limited to the bay or breakers covered under this specification. Suitable panels (if required) to mount these are also included in the scope of the work.

o) In case of distributed Bus bar Protection, the bay units for future bays may be installed in a separate panel and the same shall be located in switchyard panel room where bus bar protection panel shall be installed.

14.18 Tee Differential Protection Relays (If Applicable)

1) **TEE-1 DIFFERENTIAL (BIAS) PROTECTION RELAY** shall
   (a) be triple pole type
   (b) have an operating time less than 30 milliseconds at 5 times the rated current
   (c) have three instantaneous high set over current units
   (d) have an adjustable bias setting range of 20-50%
   (e) have an operating current setting of 15% of 1 Amp or less

2) **TEE-2 DIFFERENTIAL (HIGH IMPEDANCE) PROTECTION RELAY** shall
   (a) be triple pole type
   (b) have operating time less than 25 milliseconds at 5 times setting
   (c) be tuned to system frequency
   (d) have current setting range of 20 to 80% of 1 Amp
   (e) be voltage operated, high impedance type
   (f) be stable for all external faults
   (g) be provided with suitable nonlinear resistors across the relay to limit the peak voltage to 1000 volts

14.19 Trip Circuit Supervision Relay

- Trip circuit supervision relay shall be provided for each pole of the breaker for both trip coils with separate DC source.
- 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.
- The relay shall have adequate contacts for providing connection to alarm and event logger.
- 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.

14.20 Master Trip Relay

- High Speed Tripping Relay shall be instantaneous (operating time not to exceed 10 milli-seconds
- The relays shall reset within 20 milli seconds
- The relay shall be re-settable/configurable from local SCADA.
- The relays shall be D.C. operated
- The relays shall 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.
- The relays shall be provided with operation indicators for each element/coil.

14.21 Other Trip Relays

- For transformer protection other trip relays for Buchholz, winding & oil temperature high, PRD etc. shall be provided as per requirement.
- These High-Speed Tripping Relays shall be instantaneous (operating time not to exceed 10 milli-seconds)
- The relays shall have adequate contacts to meet the requirement of scheme

14.22 DC Supply Supervision Relay

- The relay shall be capable of monitoring the failure of D.C. supply to which, it is connected.
- It shall have adequate potential free contacts to meet the scheme requirement.
- The relay shall have a 'time delay on drop-off' of not less than 100 milli seconds and the relays shall be provided with operation indicator/flag.

14.23 TIME SYNCHRONISATION EQUIPMENT:

- The equipment must be Type tested for Shock, Vibration, Dry heat, Radiated Emission, Electromagnetic field immunity, Electrostatic discharge immunity test in a Standard Laboratory. Type test report shall be submitted along with the bid. Type tests shall be more than five years as on opening of this bid.
- The equipment shall be compliant to IEC 61850 Protocol. It shall also support the network protocols like NTPv4, SNTP, SNMPv1,2,3, SNMP Trap, SSH2, Ipv6, DHCP, HTTP (S), eMail, FTP, TELNET and Syslog
- The Time synchronisation equipment shall receive the coordinated Universal Time (UTC) transmitted through Geo Positioning Satellite System (GPS) and synchronise equipment to the Indian Standard Time in a substation.
- Time synchronisation equipment shall include antenna, all special cables and processing equipment etc.
- It shall be compatible for synchronisation of Event Loggers, Disturbance recorders and SCADA at a substation through individual port or through Ethernet realised through optic fibre bus.
- Equipment shall operate up to the ambient temperature of 50 degree centigrade and 100% humidity.
- The synchronisation equipment shall have 20 nano second accuracy. Equipment shall give real time corresponding to IST (taking into consideration all factors like voltage, & temperature variations, propagation & processing delays etc.) including communication time for satellite link to achieve real time signal.
- Equipment shall meet the requirement of IEC 60255 for storage & operation.

- The system shall be able to track the satellites to ensure no interruption of synchronisation signal.
- The output signal from each port shall be programmable at site for either one hour, half hour, minute or second pulse, as per requirement.
- 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:

  1) Voltage signal: Normally 0-5V with 50 milli Seconds minimum pulse duration. In case any other voltage signal required, it shall be decided during detailed engineering.
  2) Potential free contact (Minimum pulse duration of 50 milli Seconds.)

3) IRIG-B
4) RS232C
5) RJ 45
6) SNTP
7) Optical
8) IEEE 1588 PTP (Applicable only for process bus automation station)

- The equipment shall have a periodic time correction facility of one-second periodicity.
- Time synchronisation equipment shall be suitable to operate from 80V-250V DC supply available at the sub-station with voltage variation of + 10% and -15%.
- . 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/SAS Panels having display size of approx. 100 mm height.
- The cable connecting Antenna and Time Synchronising unit should be run through HDPE pipe or GI pipe from the location of Antenna fixing to Time Synchronising panel with suitable fixtures and no provision to enter rainwater and should not be affected by atmospheric conditions.
- Time Synchronisation software shall be window base and it should be provided free of cost after commissioning**.**

14.24 BAY CONTROL UNIT (BCU)

- The BCU must be type tested at KEMA/Internationally or nationally acreditted other testing laboratories for IEC 61850 and other tests as per relevant IEC standards. The bidder is to submit type test reports along with the bid. The validity of type test report shall be as per Clause 14.4.2(iii).

- The bay unit shall use industrial grade components. The BCU shall be modular type. The bay level unit, based on microprocessor technology, shall use numerical techniques for the calculation and evaluation of externally input analogue signals. These shall incorporate select- before-operate control principles as safety measures for operation via the HMI. These 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. These shall be directly connected to the switchgear. The bay unit shall acquire and process all data for the bay (Equipment status, fault indications, measured values, alarms etc.) and transmit these to the other devices in sub-station automation system. In addition, these shall receive the operation commands from station HMI and SLDC. The bay unit shall have the capability to store all the data for at least 24 hours even if there is any power off conditions during the day. **The BCU shall have Auto Reclose, LBB, U/O voltage and Synchronization function. The BCU shall have redundant power supply card i.e. in case of failure of one source/Card fail, the redundant shall pick up instantly. Power supply card failure shall generate necessary alarm to local SCADA.**

- The BCU must have metering functions like phase current, phase voltages, active & apparent power, power factor, frequency etc. The metering functions shall be accurate for a minimum of 1% of rated current.

- BCU HMI shall display complete mimic of the respective bay, and operator shall be able to select the equipment in the mimic diagram for which operation of equipment is required. The control operation shall be password protected. For 33kV, the HMI should display one bay and control thereof.

- The mimic diagram shall indicate the live & dead portion of the Bay.

- The BCU shall be capable to generate password for maintenance shutdown.
- One Bay level unit shall be provided for supervision and control of each 400KV, 220KV, 132kV and 33kV bay (a bay comprises of one circuit breaker and associated disconnectors, earth switches and instrument transformer). If the 33kV bus section comprises isolator only, then the isolator shall be controlled from the transformer LV side bay and same is the case for Bus PT Isolator which shall be controlled by Transformer LV side BCU. The Bay level unit shall be equipped with analogue and binary inputs/outputs for handling the control, status monitoring and analogue measurement functions. All bay level interlocks are to be incorporated in the Bay level unit so as to permit control from the Bay level unit/ local bay mimic panel, with all bay interlocks in place, during maintenance and commissioning or in case of contingencies when the Station HMI is out of service.
- The BCU shall have sufficient number of BI/BO as per the scheme requirement with additional 30% spare BI/BO.
- The Bay level units shall be installed in the control and relay panels located in the control room.
- 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.
- **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 SF6 Gas Pressures, Operating Mechanism Pressures, WTIs, OTI etc. are received through transducers to Bay Level Unit

  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.
- **Operator Interface**

  The HMI of BCU shall display the following informations
  i) the bay name
  ii) the date and time
  iii) the Local / Remote/Maintenance bay mode
  iv) the auto-recloser function status (on / off),
  v) the synchrocheck function status (on / off),
  vi) the interlock function status (on / off),
  vii) a list of measurements (in real value)
  viii) the bay graphical representation
  ix) the bay events classified in a chronological order
  x) the bay alarms
  xi) the list of disturbance records available
  xii) Bay interlock diagram

In addition, it shall be possible to plug a PC laptop on the Bay and get the full substation operator interface.

14.25 SWITCHED ETHERNET COMMUNICATION INFRASTRUCTURE:

The bidder shall provide the redundant managed switched optical Ethernet communication infrastructure for SAS against PRP architecture. The necessary switches are provided for communication infrastructure as follows.

14.25.1 One switch shall be provided to connect all IEDs for 1 Bay in LAN –I and the second optical port of Bay IEDs shall be connected to other Ethernet Switch in LAN-2. The maximum number of bays may be connected to these Ethernet Switch shall be two bays for 400KV, 220kV and 132kV. However, for 33kV, 3 numbers bay may be connected to one Ethernet Switch in this PRP architecture. The exact no of Ethernet switches required for complete implementation of the scheme shall decided during detailed engineering.

14.25.2 The managed Ethernet switch shall have minimum 20% port redundancy (Both Fibre & Copper ports).

14.25.3 Ethernet Switches shall have redundant power card.

14.25.4 Port monitoring softwares for Ethernet Switches are to be provided.

14.25.5 The make of the Ethernet switches shall be Ruggedcom/Hirschman/ABB.

14.26 FAULT RECORDER:

14.26.1 The fault recorder shall be provided for transmission line and the fault recorder as in-built feature of line distance relay is also acceptable provided the requirements of following clauses are met.

14.26.2 Fault recorder shall be capable 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.

14.26.3 The Fault recorder shall consist of individual acquisition units, one for each feeder and an Evaluation unit (as described in section sub-station automation through bus conforming to IEC 61850) which is common for the entire Substation. Necessary hardware and software shall also be supplied for online transfer of data from all acquisition units to Evaluation unit.

14.26.4 Fault recorder shall have at least 8 analogue and 16 digital channels for each feeder.

14.26.5 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.

14.26.6 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.

14.26.7 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.

14.26.8 The evaluation unit hardware shall be as described in clause no. 4.0 of section sub-station automation.

14.26.9 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.

14.26.10 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)

14.26.11 The Evaluation unit shall be connected to the printer to obtain the graphic form of disturbances whenever desired by the operator.

14.26.12 Fault recorder acquisition units shall be suitable to operate from 220V DC as available at sub-station Evaluation unit along with the printer shall normally be connected to 230V, single phase AC supply. In case of failure of AC supply, Evaluation unit and printer shall be switched automatically to the station DC through Inverter of adequate capacity which shall form a part of Distance recorder system. The inverter of adequate capacity shall be provided to cater the requirement specified in section sub-station automation clause no. 8.0 and DR evaluation unit.

14.26.13 The acquisition unit shall have the following features:

i) 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.

ii) The frequency response shall be 5 Hz on lower side and 250 Hz or better on upper side.

iii) Scan rate shall be 1000 Hz/channel or better.

iv) 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.

v) The open delta voltage and neutral current shall be derived either through software or externally by providing necessary auxiliary transformers.

vi) The acquisition unit shall be typically used to record the following digital channels:

1. Main CB R phase open
2. Main CB Y phase open
3. Main CB B phase open
4. Main-1 carrier received
5. Main-1 protection operated
6. Main/Tie /TBC Auto reclosed operated
7. Over Voltage -Stage-1 /2 operated
8. Reactor / Stub/TEE-1/2/UF protection operated
9. Direct Trip received
10. Main-2 carrier received

11. Main- 2/ Back Up protection operated
12. Bus bar protections operated
13. LBB operated of main /tie/TBC circuit breaker
14. Tie/TBC CB R phase open
15. Tie/TBC CB Y phase open
16. Tie/TBC CB B phase open

vii) In case the Fault recorder is in-built part of line distance protection, above digital channels may be interfaced either externally or internally.

viii) Any digital signal can be programmed to act as trigger for the acquisition unit. Analogue channels should have programmable threshold levels for triggers and selection for over or under levels should be possible.

14.26.14 The printer shall be compatible with the desktop PC and shall use Plain paper. The printout 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 paper (500 sheets in each packet) suitable for printer shall be supplied.

14.26.15 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.

i) Voltage signal: (0-5V continuously settable, with 50m Sec. minimum pulse duration).
ii) Potential free contact (Minimum pulse duration of 50 m Sec.)
iii) IRIG-B/SNTP
iv) RS232C/RS485/RJ 45/Optical port.

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

14.27 DISTANCE TO FAULT LOCATOR:

14.27.1 The Distance to Fault Locator shall be provided for transmission line and the fault locator as in-built feature of line distance relay is also acceptable provided the requirements of following clauses are met.

14.27.2 Distance to Fault Locator shall be electronic or microprocessor based and ‘Online’ type with built-in display unit.

14.27.3 The display shall be directly in percent of line length or kilometers without requiring any further calculations.

14.27.4 It shall have an accuracy of 3% or better for the typical conditions defined for operating timings measurement of distance relays. The accuracy should not be impaired under the following conditions:

i) presence of remote end in-feed
ii) predominant D.C. component in fault current
iii) high fault arc resistance
iv) severe CVT transients

14.27.5 It shall have mutual zero sequence compensation unit if fault locator is to be used on double circuit transmission line.

14.28 PROTECTION SCHEME FOR PANELS:

- **400KV Line Panel**

The following protections scheme shall be provided for Panels for 400 KV Transmission lines:

Main Protection Scheme I & II:

Distance protection scheme using Numerical Relay as specified in detail in Clause 14.15 and 14.16.2 shall be implemented. The summary of the scheme detailed in the above clauses have the following feature:

(i) Permissive under reach/over reach/ blocking communication mode.
(ii) Suitable for single cum three phase tripping.
(iii) Power swing blocking and out of step protection.
(iv) Single shot single-cum-three phase auto re-closing with check synchronising and deadline charging features.
(v) Fuse failure protection.
(vi) Weak end in feed feature.
(vii) Over/Under Voltage Protection
(viii) Directional Over current and Earth Fault protection
(ix) Current reversal guard feature
(x) Stub protection function
(xi) Load encroachment blinder feature.
(xii) Switch on to fault feature.
(xiii) In built Broken Conductor detection feature.
(xiv) Shall have df/dt functions
(xv) Under frequency protection
(xvi) Carrier Aided Tripping
(xvii) Main 1 and Main 2 relay shall of different make **and model**.

- **220 KV Line Panel**

The following protections scheme shall be provided for Panels for 220 KV Transmission lines:

a) Main Protection Scheme I & II:

Distance protection scheme using Numerical Relay as specified in detail in Clause 14.15 and 14.16.2 shall be implemented. The summary of the scheme detailed in the above clauses have the following feature:

(i) Permissive under reach/over reach/ blocking communication mode.
(ii) Suitable for single cum three phase tripping.
(iii) Power swing blocking and out of step protection.
(iv) Single shot single-cum-three phase auto re-closing with check synchronising and deadline charging features.
(v) Fuse failure protection.
(vi) Weak end in feed feature.

(vii) Over/Under Voltage Protection

(viii) Directional Over current and Earth Fault protection

(ix) Current reversal guard feature

(x) Stub protection function

(xi) Load encroachment blinder feature.

(xii) Switch on to fault feature.

(xiii) In built Broken Conductor detection feature.

(xiv) Shall have df/dt functions

(xv) Under frequency protection

(xvi) Main 1 and Main 2 relay shall of different **make and model**.

- **132 KV Line Panel**
  The following protections scheme shall be provided for Panels for 132 kV Transmission lines:

  a) Main Protection Scheme I:

  Distance protection scheme using Numerical Relay as specified in Clause 14.15 and 14.16.2.

  b) Backup Protection:

  The backup protection shall be provided with directional single/ multi pole relays as specified in Clause 14.16.4. One triple pole over current relays for phase faults and one Earth Fault Relay for Earth Faults without high set elements shall be provided.

- **33KV Feeder Protection Panel**

  The 33kV Feeder Panels shall be provided non directional single/ multi pole relays as specified in Clause 14.16.4. One triple pole over current relays for phase faults and one Earth Fault Relay for Earth Faults with high set elements shall be provided.

- **Power and Auto Transformer Protection Panel**
  Integrated Transformer protection scheme as detailed in Clause 14.16.3 of the BID shall be provided for Panels for all Power and Auto Transformers:

  (a) Main Protection -1

  Biased transformer differential protection employing relay type specified in Clause 14.32. The scheme shall include also following:
  (i) Second and fifth harmonic restraint feature.
  (ii) The relay shall also provide Restricted Earth Fault Protection
  (iii) The scheme shall have suitable input and output for transformer auxiliary protection like Buchholz, oil temperature, winding temperature etc.
  (iv) Over-fluxing protection
  (v) The relay shall have Back up protection features i.e Directional over current and earth fault with high set element. The high set unit should not operate due to transformer in-rush current.

  (b) Main Protection - 2

Protection function shall be same as Main Protection – I.

(c) Backup Protection: The backup protection shall be provided with Directional relays as specified in Clause 14.16.3. One triple pole over current relays f or phase faults and one Earth Fault Relay for Earth Faults with high set elements shal l be provided. The high set unit should not operate due to transformer in-rush current.

- **Bus Bar Differential Protection Panel:**
- The Bus Bar Protection shall be provided as detailed in Clause 14.17 of the BID for 400kV, 220kV and 132kV Voltage Level.

- **Reactor Protection Panel:**

The Reactor Protection shall be provided as detailed in Clause 14.16.5 of the BID.

14.29 RELAY MAINTENANCE TOOL KIT

MAINTENANCE TOOL KIT

- The bidder shall supply a complete maintenance tool kit set. The tool kit shall have generally current jack, card extender, card puller, required crimping tool, screw drivers, pliers etc.
- The tool kit shall contain test plugs, test leads, clips for maintenance and testing of relays supplied. Further detailing will be done during detail engineering.
- The Maintenance Tool Kit shall be of Universal type.

14.30 TESTS

- The supplier shall carryout all tests as per relevant standards as all associated equipment including relays, meters, instruments etc. The supplier shall submit all that reports to Employer for approval before despatching the control and relay panels. The Bidder shall also submit along with the bid type test reports for relays instruments, meters and other devices of the type and class being offered. Bidder has to submit KEMA test certificate for Numeric relay on interoperability compliance of IEC 61850 in general and GOOSE messaging and publishing in particular along with the bid.
- Control and relay panels shall be subjected to the following tests:

a. Mechanical operation test.
b. Verification of degree of protection.
c. High voltage test (2000 volts for 1 minute)
d. Electrical control interlock and sequential operation test.
e. Verification of wiring as per approved schematic.
f. Interoperability test as per IEC 61850 (interoperability with ABB, AREVA, SIEMENS, GE and SEL)

14.31 PRE-COMMISSIONING TESTS

- The contractor shall have to perform following minimum Pre-commissioning tests for commissioning of the C&R panels. For this purpose, the contractor shall arrange all required tools and testing equipment at site

(i). IR values of all circuits
(ii). Measurement of burden in CT & PT circuits
(iii). Primary current injection of CT circuits with connected burden
(iv). Energisation of PTs at suitable low voltage and measurement of PT inputs at all measuring points
(v). Secondary ac current injection of relays, dynamic testing of all numeric relays. Tracing of zone curves, limits. Checking of relay timings, inherent or set values. For this testing, the contractor shall bring ‘Omicron’ or equivalent test kit.
(vi). Testing of voltage related elements like directional element, over fluxing, over/ under frequency, over/ under voltage features, tracing of curves and checking limits of set values and associated timings
(vii). Checking of Boolean logic gates, BI/BO points of the numeric relays, checking conformity to specification and checking of set logics
(viii). Checking of stability and sensitivity of differential zones by suitably applying 3-phase low voltages and shorting of primary circuits. Measurements of voltage and current inputs to all relays.
(ix). Checking stability & sensitivity of bus differential relay zones by suitably injecting current
(x). Primary injection of REF connected CTs, measurements of relay inputs and checking of stability and sensitivity of REF scheme
(xi). Checking registration of event and disturbance records in the numeric relays and downloading
(xii). Testing of carrier aided protection schemes and simulation with regard to transmission and receipt of protection signalling
(xiii). Testing of AR schemes
(xiv). Checking of healthiness of each dc circuit of panels
(xv). Simulation of faults like Buchholz, OTI, WTI and other relays and checking of tripping of breaker and connected annunciation
(xvi). Operation of master trip relays, tripping of breaker through each trip coil and checking of interlocks
(xvii). Simulation of faults like low gas, air pressure and checking operation of interlocks. Checking anti pumping scheme of CB
(xviii). Simulation to Check Checking of PT selection schemes
(xix). Simulation to Check interlocks of all CB and isolator interlocks
(xx). Simulation to Check annunciation of all events in BCU (Bay control unit) as well as SAS (Sub-station Automation System)
(xxi). Simulation to Check of logic of BCU
(xxii). Operation of tap changing of transformer through SAS
(xxiii) The pre-commissioning checklist will be further developed by the contractor and will seek approval prior to commencement of pre-commissioning tests from the DGM, MRT Circle, AEGCL. The tests will be witnessed and approved by him or by his authorized officers.

14.32 TECHNICAL DATA SHEET FOR THE RELAY AND CONTROL PANELS

- Features to be provided in various Relay and Control panels are indicated below. Description below are only indicative; the Contractor shall ensure that all items are included in their offer to complete the schemes described in the Specification whether such items are specifically mentioned or not.

400kV and 220kV Feeder Panels:

SL NO	ITEM	RATINGS AND PARTICULARS	
		400KV Panel with 1 1/2 Breaker Scheme	220KV Panel with Main I & Main II
I	II	III	IV
A	**LINE PANELS**		
1	**Protection and relays:**		
	(a) Distance Protection Scheme I	1 No.	1 No.
	(b) Distance Protection Scheme II	1 no	1 no
	(c) LBB Protection Scheme.	Can be function of BCU/IEDs	Can be function of BCU/IEDs
	(d) Trip Circuit Supervision Relay for pre and post-closing	Supervision for 6 trip coils (2 trip coils per pole or phase)	Supervision for 6 trip coils (2 trip coils per pole or phase)
	(e) DC Supply healthy monitoring scheme for two separate DC source	2 No.	2 No.
	(e 1)DC Changeover Relay	2 Nos	2 Nos
	(f) AC Supply healthy monitoring scheme	1 No.	1 No.
	(g) High Speed Trip relay (1 & 3 pole)	2 sets.(each set will comprise of 3 Nos of 1ph trip relay and 1 No of 3ph trip relay)	2 sets.(each set will comprise of 3 Nos of 1ph trip relay and 1 No of 3ph trip relay)
	(h) PT-CVT Selection Scheme with PT1-PT2–CVT selection relay	1 Set. Complete Bus PT1-Bus PT2-CVT Selection Scheme	1 Set. Complete Bus PT1-Bus PT2-CVT Selection Scheme
	(i) Auxiliary relay, timer relay for healthiness of relays, auto reclose communication link etc.	As required (Can be function of BCU)	As required (Can be function of BCU)
	(j) Trip Transfer Relay	-	2 sets
	(j) Fault Recorder	1 set (shall be function of IED)	1 set (shall be function of IED)
	(k) Distance to fault locator	1 set (shall be function of IED)	1 set (shall be function of IED)
	(l) Under Voltage protection relay for isolator/earth switch Interlock	2 nos	2 nos
	(m) Over Voltage Protection Scheme	1 set (maybe function of IED)	1 Set (maybe function of IED)
2	**Meters**		
	(a) ABT tri-vector Meter (SAMAST Compliant) with TTB	1No	1No

3	**Controls/ Status indication/ Annunciation**		
	Bay control unit (IED)	1No. (Function of BCU/ SAS)	1No. (Function of BCU/ SAS)

132kV and 33kV feeder Panels:

SL NO	ITEM	RATINGS AND PARTICULARS	
		132 kV Panel with Main & Transfer Bus Scheme	33 kV feeder panel with single bus system
		V	VI
A	**LINE PANELS**		
1	**Protection and relays:**		
	(a) Distance Protection Scheme	1 No.	-.
	(b) Back up directional over current and earth fault scheme	1 Set	-
	(c) Back up non directional over current and earth fault scheme	-	1 set
	(d) LBB Protection Scheme.	Can be function of BCU/IEDs	Can be function of BCU/IEDs
	(e) Trip Circuit Supervision Relay for pre and post-closing	Supervision for 2 trip coils	Supervision for 2 trip coils
	(f) DC Supply healthy monitoring scheme, for two DC source	2 No.	2 No.
	(f 1) DC Changeover	2 Nos	2 Nos
	(g) AC Supply healthy monitoring Scheme	1 No.	1 No.
	(h) High Speed Trip relay	2 No.	2 No.
	(h1) High Speed Trip Relay for LBB	1 No	1 No
	(i) Auxiliary relay, timer relay for healthiness of relays, auto reclose communication link etc.	As required (Can be function of BCU)	As required (Can be function of BCU)
	(j) Trip Transfer Relay	2 sets	2 sets
	(j) Line CVT-Bus PT selection relay	1 No	-
	(k) 33kV Incomer PT selection	-	-
	(l) Distance to Fault Locator	1 set (shall be function of IED)	-
	(m) Fault Recorder	1 set (shall be function of IED)	
	(l) Under Voltage protection relay	2 nos **(function of IED)**	

	for isolator/earth switch Interlock		
	(m) Over Voltage Protection Scheme	1 set (maybe function of IED)	
2	**Meters**		
	(a) ABT tri-vector Meter (SAMAST Compliant) with TTB	1 No	1 No
3	**Controls/ Status indication/ Annunciation**		
	Bay Control Unit (IED with HMI)	1No. (Function of BCU/ SAS)	1No.

Transformer Protection Panels

SL NO	ITEM	RATINGS AND PARTICULARS			
		400/220/33 kV Transformer Panel	220/132 kV Transformer Panel	220/33 kV Transformer Panel	132/33kV Transformer Panel
		VII	VIII	IX	X
B	**TRANSFORMER PANELS**				
1	**Protection and Relays:**				
	(a) Differential Protection Scheme	2 No.	2 No.	2 No.	2 No.
	(b) Restricted Earth Fault Protection Scheme	(inherent High imp REF)	(inherent High imp REF)	(inherent High imp REF)	(inherent High imp REF)
	(c) Back up directional over current scheme and earth fault scheme for HV side.	Could be feature of relay	Could be feature of relay	Could be feature of relay	Could be feature of relay
	(d) Back up directional over current and earth fault scheme for MV/LV Side.	Could be feature of relay	Could be feature of relay	Could be feature of relay	Could be feature of relay
	(e) LBB Protection Scheme.	Can be function of BCU/IEDs	Can be function of BCU/IEDs	Can be function of BCU/IEDs	Can be function of BCU/IEDs
	(f) Over Fluxing Protection scheme	Can be function of IED	Can be function of IED	Can be function of IED	Can be function of IED
	(g) Overload protection scheme	Can be function of IED	Can be function of IED	Can be function of IED	Can be function of IED
	(g.1)Tertiary Side O/C and Open Delta Voltage Protection	1 set	1 set	-	-
	(h) Trip Circuit Supervision Relay Scheme for ascertaining pre and post-closing healthiness.	Supervision for 4/12 trip coils(2trip	Supervision for 4/8 trip coils(2 tripcoils per	Supervision for 4/8 trip coils(2 tripcoils per	Supervision for 4 trip coils(2 tripcoils per breaker on

		coilsper pole/ breaker on each side)	pole/ breaker on each side)	pole/breaker on each side)	each side)
	(i) DC Supply healthy monitoring scheme	**2 No.**	**2 No..**	2 No.	2 No.
	(i1)DC Changeover Relay	2 No.	2 No.	2 No.	2 No.
	(j) AC Supply healthy monitoring scheme	1 No.	1 No.	1 No.	1 No.
	(k) High Speed Trip relay (HV Side)	2 No.	2 No.	2 No.	2 No.
	(l) High Speed Trip relay (MV/LV Side)	2 No.	2 No.	2 No.	2 No.
	(m) Trip Transfer Relay	2 sets	2 sets	2 sets	2 sets
	(m) PT Selection Scheme on HV / MV/LV Side as applicable	1No. Complete Bus PT Selection Scheme (Can be function of BCU)	1No. Complete Bus PT Selection Scheme (Can be function of BCU)	1No. Complete Bus PT selection scheme (can be function of BCU)	1No. Complete Bus PT selection scheme (can be function of BCU)
	(m1) PT Selection Relay	3 Nos for HV/ 2 Nos for LV	2 Nos for HV/ 2 No for MV	2 Nos for HV/ 2 No for LV	1 No for HV/ 2 No for LV
	(n) Tripping relay for Bucholtz, PRD, WTI,OTI , OSR etc.	As required	As required	As required	As required
	(o) Alarm auxiliary for Bucholtz, PRD, WTI,OTI, MOG , Air Cell leakage etc.	As required (Can be a function of BCU)	As required (Can be a function of BCU)	As required (Can be a function of BCU)	As required(Can be a function of BCU)
	(p) Transformer tap position status/ raise & lower	Can be a function of BCU	Can be a function of BCU	Can be a function of BCU	Can be a function of BCU
	(q) Reverse Power Protection	Can be function of IED	Can be function of IED	Can be function of IED	Can be function of IED
2	**Meters**				
	(a) ABT tri-vector Meter (SAMAST Compliant) With TTB	2 No. (on 400kV and 220 kV side)	2No. (on 220 kV and 132 kV side)	2No. (on 220 kV and 33kV side)	2 Nos. (132 kV & 33 kV side)
3	**Controls / interlocks / Status indication/ Annunciation**				
	Bay Control Unit (IED), one no each for HV & LV side.	2 Nos. (Function of BCU/ SAS)	2 Nos. (Function of BCU/ SAS)	2 Nos. (Function of BCU/ SAS)	2 Nos. (Function of BCU/ SAS)

Reactor Protection Panel

The Reactor Protection Panel shall consist of following protection features/schemes:

SL. NO	**Description**	**400 kV**
		XI
1	Reactor Differential Protection scheme	1 No
2	Restricted Earth fault Protection scheme:	1 No
3	Reactor back up impedance protection scheme	1 Set
4	Three phase trip relays (Only for Bus Reactor)	2 Nos.
5	CVT selection relay as per scheme requirement	Lot

400kV, 220 kV and 132 kV Bus Coupler / Bypass Breaker Panel

SL NO	ITEM	RATINGS AND PARTICULARS	
		220 kV Panel with Main I & Main II Scheme	132 kV Panel with Main 1 & Transfer Bus Scheme
		XII	**XIII**
A	**BUS COUPLER PANEL**		
1	**Protection and relays:**		
	(a) Back up directional over current and earth fault scheme	1 Set	1 Set
	(b) Bus Bar differential protection	Main I and Main II	Applicable, where specified in BoQ
	(c) LBB Protection Scheme.	Can be function of BCU/IEDs	Can be function of BCU/IEDs
	(d) Trip Circuit Supervision Relay for pre and post-closing	Supervision for 6 trip coils (2 trip coil for each Phase)	Supervision for 2 trip coils
	(e) DC Supply healthy	2 No.	2 No.

	monitoring scheme		
	(e)DC Changeover Relay	2 No.	2 No.
	(f) AC Supply healthy monitoring scheme	1 No.	1 No.
	(g) High Speed Trip relay	2 Sets. .(each set will comprise of 3 Nos of 1ph trip relay and 1 No of 3ph trip relay)	2 No.
	(h) PT Selection Scheme	1No. Complete Bus PT Selection Scheme (Can be function of BCU)	Not applicable
	(i) Auxiliary relay, timer relay scheme	As required	As required
2	**Metering**	Function of BCU/ SAS	Function of BCU/ SAS
3	Controls/Annunciation/Statusindication		
	Bay control unit (IED)	1 No. (Function of BCU/ SAS)	1 No. (Function of BCU/ SAS)

400kV Tie Breaker Panel

SL NO	ITEM	Ratings and Particulars
		4000 kV Panel with 1 $^{1/2}$ Breaker Scheme
		XIV
B	**TIE PANEL**	
1	**Protection and relays:**	
	(a) Back up directional over current and earth fault scheme	
	(b) Bus Bar differential protection	
	(c) LBB Relay.	1 No
	(d) Trip Circuit Supervision Relay for pre and post-closing	Supervision for 6 trip coils (2 trip coils per pole or phase)
	(e) DC Supply healthy monitoring scheme	2 No.
	(f) DC Changeover Relay	2 No
	(f) AC Supply healthy monitoring scheme	1 No.
	(g) High Speed Trip relay	2Sets. (each set will comprise of 3 Nos of 1ph trip relay and 1 No of 3ph trip relay)

	(h) Auxiliary relay, timer relay scheme	As required
2	**Metering**	Function of BCU/ SAS
3	Controls/Annunciation/Status indication	
	Bay control unit (IED)	1 No.

14.33 Monitoring, Control & Protection for Auxiliary Transformer

Suitable monitoring, control (operation of associated Circuit breaker and isolator) and protection for LT Auxiliary Transformer, connected to tertiary winding of auto transformer for the purpose of auxiliary supply shall be provided by the contractor. Overcurrent and open delta protection is required to be provided for the auxiliary transformer. These control and protection shall also be acceptable as built in feature either in the bay controller to be provided for the auxiliary system or in the control and protection IEDs to be provided for the auto transformer.

NOTE: **1) The relays (main / auxiliary) not covered within the above table shall be considered for complete commissioning of the protection scheme.**

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)Relay setting template (in editable document format) shall be provided by the Contractor for each typical protection IEDs for relay setting purpose.

4)For GIS Sub Stations, GIS Gas Zone trip signals, if provided, for each gas tight compartments (gas zone) in the GIS LCC shall be integrated in the protection schematics to provide electrical isolation of faulty Gas Zone by tripping/ inter tripping its adjacent circuit breakers. The scheme shall be implemented through protection IEDs and auxiliary relay as required.

CHAPTER 15: SUB STATION AUTOMATION SYSTEM

15.1 GENERAL

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 for at least 3 (three) years as on the date of bid opening.*** KEMA/ Internationally and nationally accreditted certificate for all IEDs and Ethernet switches conforming to IEC 61850 is to be furnished as qualification requirement.

Standards

Environment Standards

All these standards are applicable to elements like HMI, Ethernet network and elements, Gateways, IEDs.

Type Test Name	Type Test Standard	Conditions
Insulation Resistance	IEC 60255-5	100 MΩ at 500 Vdc (CM & DM)
Dielectric Withstand	IEC60255-5 IEEE C37.90	50 Hz, 1mn, 2kV (CM), 1kV (DM)
		50 Hz, 1mn, 1kV (CM)
		G 1.4 & 1.5 500V CM G 6 :1,5 kV CM
High Voltage Impulse Test	IEC 60255-5	5kV (CM), 3kV (DM)
		2kV (CM)
		Groups 1 to 6 :5 kV CM & 3 kV DM(1)
		Not on 1.4 & 1.5 : 5 kV CM & 3 kV DM(1)
Free Fall Test Free Fall Packaging Test	IEC 60068-2-31 IEC 60068-2-32	Test Ec : 2 falls from 5cm Test Ed : 2 falls from 0,5m
		2 falls of 5 cm (Computer not powered)
		25 falls of 50 cm (1) (2) (Packaging computer)
Vibration Response – Powered On	IEC 60255-21-1	Class 2 : 1g from 2 to 150Hz
		Classe 2 : Acceleration : 1g from 10 (1) to 150Hz
Vibration Response – Not Powered On	IEC 60255-21-1	Class 2 : 2g from 2 to 500Hz
		Classe 2 : Acceleration : 2g from 10 (1) to 500Hz
Vibration Endurance – Not Powered On	IEC 80068-2-6	Class 2 : 1g from 10 to 150Hz
		Class 2 : Acceleration : 1g from 10 (1) to 500Hz

Shocks – Not Powered On	IEC 60255-21-2	Class 1 : 15g, 11 ms
Shocks – Powered On	IEC 60255-21-2	Class 2 : 10g, 11 ms
Bump Test – Not Powered On	IEC 60255-21-2	Class 1 : 10g, 16ms, 2000/axis
Seismic Test – Powered On	IEC 60255-21-3	Class 1 : Axis H : 3,5mm – 2g Axis V : 3,5mm – 1g
		Classe 2 : Acceleration : 2g Displacement : 7,5mm selon axe H Acceleration : 1g Displacement : 3,5mm selon axe V
Damp Heat Test - Operating	IEC 60068-2-3	Test Ca : +40°C / 10 days / 93% RH
Cold Test - Operating	IEC 60068-2-1	Test Ab : -10°C / 96h
		Test Ab : - 25°c / 96 H
Cold Test - Storage	IEC60068-2-1	Test Ad : -40°C / 96h Powered On at –25°C (for information) Powered On at –40°C (for information)
Dry Heat Test – Operating	IEC 60068-2-2	Test Bd : 55°C / 96h
		70°C / 2h
		70°c / 24 H
Dry Heat Test – Storage	IEC 60068-2-1	Test Bd : +70°C / 96h Powered On at +70°C
Enclosure Protection	IEC 60529	Front : IP=52 Rear : IP=30
Inrush current (start-up)		T < 1,5 ms / I < 20 A T < 150 ms / I < 10 A T > 500 ms / I < 1,2 In
Supply variation	IEC 60255-6	Vn +/- 20% Vn+30% & Vn-25% for information
Overvoltage (peak withstand)	IEC 60255-6	1,32 Vn max 2 Vn during 10 ms (for information)

Supply interruption	IEC 60255-11	From 2,5 ms to 1 s at 0,8 Vn 50 ms at Vn, no malfunction (for information)
40 s interruption	IEC 60255-11	
Ripple (frequency fluctuations)	IEC 60255-11	12% Vn at f=100Hz or 120Hz 12% Vn at f=200Hz for information
Supply variations	IEC 60255-6	Vn +/- 20%
AC Voltage dips & short interruptions	EN 61000-4-11	2ms to 20ms & 50ms to 1s 50 ms at Vn, no malfunction (for information
Frequency fluctuations	IEC 60255-6	50 Hz : from 47 to 54 Hz 60 Hz : from 57 to 63 Hz
Voltage withstand		2 Vn during 10 ms (for information)
High Frequency Disturbance	IEC 60255-22-1 IEC 61000-4-12 IEEE C37.90.1	Class 3 : 2.5kV (CM) / 1kV (DM)
		Class 2 : 1kV (CM)
Electrostatic discharge	IEC 60255-22-2 IEC 61000-4-2	Class 4 : 8kV contact / 15 kV air
Radiated Immunity	IEC 60255-22-3 IEC 61000-4-3	Class 3 : 10 V/m – 80 to 1000 MHz & spot tests
	IEEE C37.90.2	35 V/m – 25 to 1000 MHz
Fast Transient Burst	IEC 60255-22-4 IEC 61000-4-4 IEEE C37.90.1	Class 4 : 4kV – 2.5kHz (CM & DM)
		Class 3 2 kV - 2,5 kHz MC
		Class 3 : 2kV – 5kHz (CM)
Surge immunity	IEC 61000-4-5	Class 4 : 4kV (CM) – 2kV (DM)
		Class 3 : 2kV (CM) on shield Class 4 : 4kV (CM) for information

		Class 3 : 1 kV MC
High frequency conducted immunity	IEC 61000-4-6	Class 3 : 10 V, 0.15 – 80 MHz
Harmonics Immunity	IEC 61000-4-7	5% & 10% de H2 à H17
Power Frequency Magnetic Field Immunity	IEC 61000-4-8	Class 4 : 50 Hz – 30 A/m permanent – 300 A/m short time
		Class 5 : 100A/m for 1mn 1000A/m for 3s
Power Frequency	IEC 61000-4-16	CM 500 V / DM 250 V via 0.1 µF
Conducted emission	EN 55022	Gr. I, class A and B : from 0.15 to 30 MHz
Radiated emission	EN 55022	Gr. I, class A and B : from 30 to 1000 MHz, 10m

Communication Standards

UCA2:
CASM 1.6 - Common Application Service Models and Mapping to MMS

GOMSFE 0.91 - Generic Object Models for Substation & Feeder Equipment

IEC 61850:
IEC 61850-8-1: *Communication networks and systems in substations – Part 8-1: Specific communication service mapping (SCSM) – Mapping to MMS(ISO/IEC 9506 Part 1 and Part 2*

Telecontrol protocol:
IEC 608670-5-101
IEC 608670-5-104.
Legacy protection protocol
IEC 60870-5-103 *International standards – First release 1997-12*
MODBUS

Automation Standard

IEC 61131-3

The Substation Automation System (SAS) shall be installed, tested and commissioned to control and monitor all the sub-station equipment from remote control center (SCADA) as well as from local SCADA.

The SAS shall contain the following main functional parts:

- Bay control Intelligence Electronic Devices (IEDs) for Control and Monitoring.
- Bay Protection Intelligent Electronic device (IEDs) for Protection as detailed in previous chapter
- Metering server (Industrial Grade) and protocol converter.
- Station Main & Hot Standby Redundant Human Machine Interface (HMI)

- Redundant managed switched Ethernet Local Area Network communication infrastructure with hot standby.
- The managed Ethernet switch shall have sufficient port redundancy (Both Fibre & Copper ports).
- The IED shall have two fiber optic ports for connecting Ethernet Switch of each LAN i.e. (PRP,architecture).
- Integrated Switches (built-in bay IEDs) are not acceptable. All the IEDs shall be directly connected to the Ethernet Interbay LAN without the use of any gateways.
- Gateway for remote control via industrial grade hardware (to SLDC) through IEC60870-5-101 & 104 protocol. All the IEDs shall be directly connected to the Ethernet PRP LAN without use of any gateways.
- The communication protocol between the bays, with the Gateway and HMI shall be UCA2/IEC 61850 in order to permit 100 Mbps peer-to-peer communications.
- Within a bay it shall be UCA2/IEC 61850 protocol.
- All IEDs shall have redundant power card.
- Gateway for Control from Remote end and State Load Dispatch Center (SLDC). The gateway should be able to communicate with SLDC on IEC 60870-5-101 & 104 protocol. The specific protocol to be implemented shall be handed over to successful bidder. It shall be the bidder's responsibility to integrate his offered system with existing SLDC system for exchange of desired data. The bidder shall ensure that proposed automation system is compatible with the existing SCADA network. Equipment required for data transfer to the existing SCADA network to interface communication equipment is in the bidder's scope of work and it will be included in the bid price.
- Gateway shall also have redundancy and redundant Gateway shall not be housed in a single cabinet. The Gateway shall also have sufficient future expandability and this shall excludes data **for all future provision bays as per Project Requirement**. The Gateways shall have redundant power cards.
- The communication link (PLCC / Fiber Optic) to SLDC is not in the scope of the bidder. However, the bidder will provide required modem both for PLCC and Fibre Optic communications to the nearest Wide Band Locations of STU/CTU which are connected to SLDC. It shall be the bidder's responsibility to integrate the offered system for desired exchange of telemetry data to SLDC.
- Redundant Local HMI & DR Work Station.
- Peripheral equipment like printers, display units, key boards, Mouse etc. 3.4.1.5. 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.
- Gateway IEDs shall have redundant power card.
- Gateway shall also have 100% redundancy for it's all functions like power, AI & BI/BO card etc. The Gateway shall also have sufficient future expandability and this shall excludes **data for all future provision bays as per Project Requirement**. The Gateways shall have redundant power cards
- **License of 15 years for the commissioned Sub Station Automation System (SAS) shall be provided.**
- **Vulnerability Audit and Penetration Testing by CERT-In empanelled firm: After successful commissioning of SAS, the successful Bidder shall do cyber Audit of the system by a CERT-In empanelled Cyber Security Auditor (to be approved by AEGCL). For that the company shall do Vulnerability assessment and**

Penetration testing of the SAS system and submit the report to AEGCL. The company shall fix any vulnerabilities found during the VA/PT.

It shall include communication gateway, intelligent electronic devices (IED) for bay control and inter IED communication infrastructure. **A model architecture drawing for SAS is enclosed at the end of this chapter as Annexure I.**

Bay level intelligent electronic devices (IED) for protection and control and the Managed Ethernet Switch shall be provided in the C&R panels installed in the local control room. Each IED will be directly connected to the Hot-standby Server PC (HMI) of the Station Automation System through a **PRP** Ethernet LAN on fiber optic medium and shall communicate as per the IEC61850 standard.

The communication gateway shall facilitate the information flow with SLDC/Remote Control Centre.

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.

The Integration of IEC61850 communication based monitoring equipment like Online Insulating Oil drying system, Digital RTCC Relays etc with substation automation system shall be carried out and shall be included in the scope of work.

Further the Gateways shall have licenses sufficient for all the bays covered in the present scope as well as all the mentioned future bays.

All the numerical IEDs must be fully IEC 61850 compliant and must have the following features.

- Have peer-to-peer communication using GOOSE messages (IEC 61850) for interlocking.
- Should be interoperable with third party IEC 61850 compliant devices
- Should generate XML file for integration/engineering with vendor independent SCADA systems.
- **Should be directly connected to the inter bay bus on IEC 61850 without the use of any gateways.** Connections of bay protection IEDs to the IEC 61850 bus through the bay control units is not acceptable.

15.2. SYSTEM DESIGN

General System Design

- The Substation Automation System (SAS) shall be suitable for operation and monitoring of the complete substation including **all future extensions as per Project Requirement**..
- The systems shall be of the state-of-the art architecture and shall be suitable for operation under electrical environment present in Extra high voltage substations, follow the latest engineering practice, ensure long-term compatibility requirements and continuity of equipment supply and the safety of the operating staff.
- The offered SAS shall support remote control and monitoring from remote SCADA via gateways.
- The system shall be designed such that personnel without any background knowledge in Microprocessor-based technology are able to operate the system. The operator interface shall be intuitive such that operating personnel shall be able to operate the system easily after having received some basic training.

- The system shall incorporate the control, monitoring and protection functions specified, self-monitoring, signaling and testing facilities, measuring as well as memory functions, event recording and evaluation of disturbance records.
- Maintenance, modification or extension of components may not cause a shutdown of the whole substation automation system. Self-monitoring of components, modules and communication shall be incorporated to increase the availability and the reliability of the equipment and minimize maintenance.
- **Bidder shall offer the Bay level unit (a bay comprises of one circuit breaker and associated isolator, earth switches and instrument transformer), bay mimic along with relay and protection panels and Station HMI in Control Room building for overall optimization.**

15.3. Ethernet Switches

Ethernet switches that fulfill the hardened requirements concerning temperature, power supply (80-250 V DC from the Station Battery) **and complying to IEC 61850** suitable to be installed in substations shall be provided, i.e. the same data as common for numerical protection. **The Managed Ethernet Switch shall have dual Power supply provision**. The use of Ethernet Hubs is not permitted as they do not provide collision free transmission. Suitable port monitoring software shall be provided for monitoring of ports healthiness and should generate alarm in SAS.

15.4. SYSTEM ARCHITECTURE

- The SAS shall be based on a PRP architecture and on a concept of bay-oriented, distributed intelligence.
- The main process information of the station shall be stored in distributed databases. The typical SAS architecture shall be structured in two levels, i.e. in a station and a bay level.
- At bay level, the IEDs shall provide all bay level functions regarding control, monitoring and protection, inputs for status indication and outputs for commands. The IEDs should be directly connected to the switchgear without any need for additional interposition or transducers. But incase of Circuit Breaker SF6 Gas Pressure, Operating Mechanism Pressure (i.e. Air/ Pneumatic, Hydraulic and Nitrogen Pressures), if SF6 CTs are Utilizing the Pressure of SF6 Gas, Transformer Oil/ Winding temperatures, fire fighting or any Other with Transformer management Relay and OLTC Tap Position & Operation can be interfaced with BCU or any Other device interface through Transducers. The tap changing operation, synchronization of sources and trip transfer operation shall be performed through the BCU in addition to above. These parameters shall appear in Substation Automation System at Local HMI.

  In GIS Sub Stations, all the gas tight chambers are required to be monitored individually phase wise for their SF6 gas density status by the bay control unit in a bay. Sufficient numbers of inputs are required to be provided in the BCU for the all the signals from the GIS Bays. In case there is any limitation of number of inputs in the BCU, additional BCUs or additional Cards(In case of Modular BCU) are required to be provided without any cost implication to AEGCL. These inputs shall be used for necessary monitoring, control and protection purpose.

  The Sub-station Automation system being offered shall generally conform to provision of IEC 62351, IEEE1686 and NERC CIP (applicable part such as CIP 003, CIP-005, and CIP-007) for cyber security.

- **Tagging for Report generation shall be provided for sufficient number of signals for incorporation of all present and future bays, including 20% spare.**
- 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 fiber optic cables, thereby guaranteeing disturbance free communication. Data exchange is to be realized using IEC 61850 protocol with a redundant managed switched Ethernet communication infrastructure.
- The communication shall be in parallel mode, and such that failure of one set of fiber shall not affect the normal operation of the SAS. However, it shall be alarmed in SAS. Each fiber optic cable shall have four (4) spare fibers. IED shall have two fibre ports and one port shall be connected to individual Ethernet Switch of each LAN.
- 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 centers.
- The GPS time synchronizing signal for the synchronization of the entire system with redundancy shall be provided.
- The SAS shall contain the functional parts as described in para above.

15.5. FUNCTIONAL REQUIREMENTS

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

- ✓ Remote control centers/SLDC
- ✓ Station HMI.
- ✓ Local Bay controller IED

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.

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.

Command Supervision

Bay/station interlocking and blocking
Software Interlocking is to be provided to ensure that inadvertent incorrect operation of switchgear causing damage and accidents in case of false operation does not take place.
It shall be a simple layout, easy to test and simple to handle when upgrading the station with future bays. For software interlocking the bidder shall describe the scenario while an IED of another bay is switched off or fails.

A software interlock override function shall be provided which can be enabled to bypass the interlocking function.

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.

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

User Configuration
The monitoring, controlling and configuration of all input and output logical signals and binary inputs and relay outputs for all built-in functions and signals shall be possible both locally and remotely.
It shall also be possible to interconnect and derive input and output signals, logic functions, using built-In functions, complex voltage and currents, additional logics (AND-gates, OR gates and timers). (Multi-activation of these additional functions should be possible).

The Functional requirement shall be divided into following levels:
a). Bay (a bay comprises of one circuit breaker and associated disconnector, earth switches and instrument transformer) Level Functions
b). System Level Functions

15.6. BAY LEVEL FUNCTIONS

In a decentralized architecture the functionality shall be as close to the process as possible. In this respect, the following functions can be allocated at bay level:

- Bay control functions **including data collection in bay control / protection unit**.
- Bay protection functions with support of Numerical Relays defined in CRP Section.

15.7. Bay Control Functions

Overview
Functions:

- Control mode selection
- Select-before-execute principle
- Command supervision:
    - ✓ Interlocking and blocking
    - ✓ Double command
- Synchro-check, voltage selection
- Run Time Command cancellation
- Transformer Tap Changer control (raise / lower tap) (for Power Transformer bays)
- Operation counters for Circuit Breakers and Pumps.
- Transformer cooling gear, pump control and runtime supervision
- Operating pressure Monitoring & supervision (CB SF6 Gas Pressure, CB Operating Pneumatic Pressure / spring status).
- Display of interlocking and blocking
- Breaker position indication (per phase for single pole)
- Alarm annunciation
- Measurement display. (Electrical Parameters & Transformer Parameters)
- Local HMI (local guided, emergency mode)
- Interface to the station HMI.
- Data storage for at least 500 events

- Extension possibilities with additional I/O's inside the unit or via fiber optic communication and process bus

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 SCADA) and the installation can be controlled only remotely. Control operation from lower levels shall not be possible in this operating mode.

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

V**oltage 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.

Transformer Tap Changer control
Raise and lower operation of OLTC taps of Transformer shall be facilitated through Bay controller IED.

Protection Transfer Control
From BCU, necessary control shall be provided for transferring bay to TBC.

15.8. Bay Protection Functions

General
The Protection functions are independent of Bay Control function. The Protection shall be provided by separate Protection IEDs (numerical relays) and other Protection devices as per section Relay & Protection.
IEDs shall be connected to the communication infrastructure for data sharing and meet the real-time communication requirements for automatic functions. The data presentation and the configuration of the various IEDs shall be compatible with the overall system communication and data exchange requirements.

Event and disturbance recording function

Each IED should contain an event recorder capable of storing at least 200 time-tagged events. This shall give alarm if 70% memory is full. The disturbance recorder function shall be as detailed in section C&R.

Bay Monitoring Functions
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.

15.9. SYSTEM LEVEL FUNCTIONS

Status Supervision

- Continuous monitoring of switching objects i.e. 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 dedicated one or more IED and all alarm and analogue values shall be monitored and recoded through this IED.

Measurements
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, Max / Min values for voltage (U) and current (I) shall be calculated.

In case of Circuit Breaker SF6 Gas Pressure, Operating Mechanism Pressure (i.e. Pneumatic, Spring), if SF6 CTs are Utilizing the Pressure of SF6 Gas, Transformer Oil/ Winding temperatures, Firefighting or any Other with Transformer management Relay and OLTC Tap Position can be interfaced with BCU through Transducers. Max / Min values for the above parameters shall be calculated. These parameters shall appear in Substation Automation System at Local HMI and can monitor regularly.

The measured values shall be displayed locally on the station HMI and in the control center. The abnormal values must be discarded. The analogue values shall be updated every 2 seconds**.**

Threshold limit values shall be selectable for alarm indications.
The SAS shall also poll data from the Meter Server to gateway for onward communication to RCC.

Event and alarm handling
Events and alarms are generated either by the switchgear, by the control IEDs, or by the station level unit. They shall be recorded in an event list in the station HMI. Alarms shall be recorded in a separate alarm list and appear on the screen. All, or a freely selectable group of events and alarms shall also be printed out on an event printer. The alarms and events

shall be time-tagged with a time resolution of 1 ms. **The tentative list of event/ alarm for various feeders and systems are enclosed as Annexure-II and is not exhaustive, there may be addition during detail engineering or at the time of commissioning.**

15.10. Station HMI

Substation HMI Operation:
On the HMI the object has to be selected first. In case of a blocking or interlocking condition 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.

Presentation and dialogues

General
The operator station HMI shall be a redundant with hot standby and shall provide basic functions for supervision and control of the substation. The operator shall give commands to the switchgear on the screen via mouse clicks or keyboard commands.

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, Pressure values (wherever required) and measured values (current, voltage, apparent power, freq & pf) including OLTC Tap Position, WTI, OTI & Analog set values.
- ✓ Control dialogues with interlocking and blocking details. This control dialogue shall tell the operator whether the device operation is permitted or blocked & Select before Execute.
- ✓ Measurement dialogues, Statistics & Trends
- ✓ Bay wise interlock status display and failure of any interlock within the bay by generating alarm and indication in Interlock diagram window.
- ✓ Alarm list, station / bay-oriented
- ✓ Event list, station / bay-oriented
- ✓ Substation Auxiliaries
- ✓ System status
- ✓ Printing of sequence of event list, hardcopy and reports. The reports shall be freely configurable using Crystal Report

List of signals to be configured in SAS is mentioned in Annexure-II of this chapter.

HMI design principles
Consistent design principles shall be adopted with the HMI concerning labels, colours, dialogues and fonts. Non-valid selections shall be dimmed out.
The object status shall be indicated using different status colours for:

- ✓ Selected object under command
- ✓ Selected on the screen

- ✓ Not updated, obsolete values, not in use or not sampled
- ✓ Alarm or faulty state
- ✓ Warning or blocked
- ✓ Update blocked or manually updated
- ✓ Control blocked
- ✓ Normal state

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 addition to above Transformer WTIs, OTI, SF6 gas Pressures of Circuit breakers , CTs and CB Operating mechanism Pressures shall also be displayed.
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.

System Supervision and Display
The SAS system shall be comprehensively self-monitoring 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, protection couplers and remote communication links, and printers at the station level, etc.

Event List
The event list shall contain events that are important for the control and monitoring of the substation.
The event and associated time (with 1ms resolution) of its occurrence has to be displayed for each event.
The operator shall be able to call up the chronological event list on the monitor at any time for the whole substation or sections of it.
A printout of each display shall be possible on the hard copy printer/Dot matrix Printer / Line Printer of 132 Column.
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 measurand.

- Loss of communication.
- Hourly time Stamping

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

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.

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
- SLDC / SAS control
- Errors
  etc. shall be displayed.

Control dialogues

The operator shall give commands to the system by means of mouse click located on the single-line diagram. It shall also be possible to use the keyboard for command activation. 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

User-authority levels

It shall be possible to restrict activation of the process pictures of each object (bays, apparatus...) 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), Shift wise operator's pass word for 3 shift in a day.
- 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 login procedure. Only the system administrator shall be able to add/remove users and change access rights.

15.11. Reports

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

Trend reports:

- Day (mean, peak)
- Month (mean, peak)
- Semi-annual (mean, peak)
- Year (mean, peak)
- Historical reports of selected analogue Values:
- Day (at 15 minutes interval)
- Week
- Month
- Year

It shall be possible to select displayed values from the database in the process display on-line. Scrolling between e.g. days shall be possible. Unsure values shall be indicated. It shall be possible to select the time period for which the specific data are kept in the memory.

Following printouts shall be available from the printer and shall be printed on demand:

i. Daily voltage and frequency curves depicting time on X-axis and the appropriate parameters on the Y-axis. The time duration of the curve is 24 hours.

ii. Weekly trend curves for real and derived analogue values.

iii. Printouts of the maximum and minimum values and frequency of occurrence and duration of maximum and minimum values for each analogue parameter for each circuit in 24 hr period.

iv. Provision shall be made for logging information about breaker status like number of operation with date and time indications.

v. Equipment operation details shift wise and during 24 hours.

vi. Printout on adjustable time period as well as on demand for MW, MVAR, Current, Voltage on each feeder and transformer as well as Tap Positions, temperatures (WTIs, OTI) and status of pumps and fans for transformers.

vii. Printout on adjustable time period as well as on demand system frequency and average frequency.

viii. Reports in specified formats which shall be developed by the contractor.

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.

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.

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

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.

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.

15.12. GATEWAY

Communication Interface
The Substation Automation System shall have the capability to support simultaneous communications with SLDC,
The Substation Automation System shall have communication ports as follows:
(a) Two Ports for RCC & State Load Dispatch Centre from each Gateway.
(b) The redundant Gateway shall work as hot stand by.
The communication interface to the SAS shall allow scanning and control of defined points within the substation automation system. The substation automation system shall simultaneously respond to independent scans and commands from employer's control centers (SLDC).

SLDC Communication Interface
Employer will supply communication channels between the Substation Automation System and the SLDC. The communication channels provided by Employer will consist either of power line carrier or optical fiber.

Interface equipment:
The Contractor shall provide interface equipment for communicating between Substation Automation system and State Load Dispatch Centre (PLCC/ FO).
In case of PLCC communication any modem supplied shall not require manual equalization and shall include self-test features such as manual mark/space keying, analogue loop-back, and digital loop-back. The modems shall provide for convenient adjustment of output level and receive sensitivity. **The modem should be stand alone complete in all respects including power supply to interface the SAS with communication channel**. The configuration of tones and speed shall be programmable and maintained in non-volatile memory in the modem. All necessary hardware and software shall also be in the scope of

bidder except the communication link along with communication equipment between substation control room and SLDC.

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

15.13. SYSTEM HARDWARE

Redundant Station HMI, and Disturbance Recorder Work station).
The contractor shall provide redundant station HMI in hot standby mode. **The servers used in these work stations shall be of industrial grade.**

It shall be capable to perform all functions for entire substation including future requirements as indicated in the SLD. It shall use industrial grade components. Processor and RAM shall be selected in such a manner that during normal operation not more than 30% capacity of processing and memory are used. Supplier shall demonstrate these features. The RAM, Hard Disk and Bus should latest and with maximum Values.
The capacity of hard disk shall be selected such that the following requirement should occupy less than 50% of disk space:
1) Storage of all analogue data (at 15 Minutes interval) and digital data including alarm, event and trend data for thirty (30) days,
2) Storage of all necessary software,
3) 500GB space for EMPLOYER'S use.

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

HMI (Human Machine Interface)
The VDU shall show overview diagrams (Single Line Diagrams) and complete details of the switchgear with a colour display. All event and alarm annunciation shall be selectable in the form of lists. Operation shall be by a user-friendly function keyboard and a cursor positioning device. The user interface shall be based on WINDOWS concepts with graphics & facility for panning, scrolling, zooming, decluttering etc.

For 400kV,220kV, 132kV Substations 70mm VDU high resolution screen showing total SLD, alarm, bay wise real time data to be displayed as shown in the model SAS architecture.

Visual Display Units/TFT's (Thin Film Technology)
The contractor shall provide three display units, one for station HMI, one for redundant HMI and one for DR work station. These shall have high resolution and reflection protected picture screen. High stability of the picture geometry shall be ensured. The screen shall be at least 25" diagonally (3:4) in size or more and capable of colour graphic displays.
The display shall accommodate resolution of 1280 X 1024 pixels or more.

Printer
It shall be robust & suitable for operation with a minimum of 132 characters per line for Line Printer and Dot Matrix Printer. 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 printers mounted in the control room shall be provided with printer enclosure. The enclosure shall be designed to permit full enclosure of the printers at a convenient level. Plexiglas windows shall be used to provide visual inspection of the printers and ease of reading. The printer enclosures shall be designed to protect the printers from accidental external contact & each should be removable from hinges at the back and shall be provided with lock at the front.
All reports and graphics prints shall be printed on **laser printer**

One Dot Matrix Printer (DMP) shall be exclusively used for hourly log printing.

Line printer for Events and Alarms Printing
All printers shall be continuously online through directly or printer server.

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 of CD-ROM & DVD-ROM with 5GB or more capacity i.e CD Writer & DVD Writer (Both). The unit should support at least Read (48X), Write (24X), and Re-Write (10X) operations, with Multi-Session capability. It should support ISO9660, Rockridge and Joliet 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**.**
All the data pertaining to Substation is to store in a system year/ month / day wise. The daily data is stored in a day file of Particular Month and Year automatically from 00.00Hrs to 24.00Hrs.

Auxiliary BCU
One BCU shall be put in Station level for monitoring Station Auxiliary Supply (AC & DC), Battery Chargers, Nitrogen Fire Fighting System, Fire alarm etc.

Furniture required for HMIs, Printers, and Operators etc. The make of furniture shall be of Godrej or better.

15.14. EXTENDIBILITY IN FUTURE
Offered substation automation system shall be suitable for extension in **future for all Future Bays as per Project Requirement.** 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..

15.15. SOFTWARE STRUCTURE
The software package shall be structured according to the SAS architecture and strictly divided in various levels. Necessary firewall shall be provided at suitable points in software to protect the system. An extension of the station shall be possible with lowest possible efforts. Maintenance, modification or an extension of components of any feeder shall not force a shut-down of the parts of the system which are not affected by the system adaptation.

15.16. 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.

15.17. Bay Level Software

System Software
The system software shall be structured in various levels. This software shall be placed in a non-volatile memory. The lowest level shall assure system performance and contain basic functions, which shall not be accessible by the application and maintenance engineer for modifications. The system shall support the generation of typical control macros and a process database for user specific data storage. In case of restoration of links after failure, the software along with hardware shall be capable of automatically synchronising with the remaining system without any manual interface. This shall be demonstrated by contractor during integrated system test.

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.

Simulation
Simulation tools shall be provided with the system to emulate a missing equipment on UCA2/IEC61850.
The simulation tools shall be set up by the system configuration tool and be able to execute scenario defined by the user.

15.18. Network Management System

The contractor shall provide a network management system software for following management functions:
a. Configuration Management
b. Fault Management
c. Performance Monitoring
This system shall be used for management of communication devices and other IEDs in the system. This NMS can be loaded in DR work-station and shall be easy to use, user friendly and menu based. The NMS shall monitor all the devices in the SAS and report if there is any fault in the monitored devices. The NMS shall
(a) Maintain performance, resource usage, and error statistics for all managed links and devices and present this information via displays, periodic reports and on demand reports.
(b) Maintain a graphical display of SAS connectivity and device status.
(c) Issue alarms when error conditions occur
(d) Provide facility to add and delete addresses and links

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

15.18(a) Cyber Security features

wherever applicable All Intelligent electronic equipment, Numerical relays, Bay control units, Bay protection units, Gateways, Transformer Tap controller/changer, etc. with IEC 61850 communication protocol shall be cyber security compliant as per latest “CEA (Cyber security in power sector) Guidelines”. Specifications shall also be compliant to latest revision of IEEE 1686

15.19. TESTS

The substation automation system offered by the bidder shall be subjected to following tests to establish compliance with IEC 61850 for EHV substation equipment and specified conditions:

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 Measured Values
ii. Currents
iii. Voltages
iv. Time resolution

c. Insulation Tests:

i. Dielectric Tests
ii. Impulse Voltage withstand Test

d. Influencing Quantities

i. Limits of operation
ii. Permissible ripples
iii. Interruption of input voltage

e. Electromagnetic Compatibility Test:

i. 1 MHZ. burst disturbance test
ii. Electrostatic Discharge Test
iii. Radiated Electromagnetic Field Disturbance Test
iv. Electrical Fast transient Disturbance Test
v. Conducted Disturbances Tests induced by Radio Frequency Field
vi. Magnetic Field Test
vii. Emission (Radio interference level) Test.
viii. Conducted Interference Test

f. Function Tests:

i. Indication
ii. Commands
iii. Measured value Acquisition
iv. Display Indications

g. Environmental tests:

i. Cold Temperature
ii. Dry Heat
iii. Wet heat
iv. Humidity (Damp heat Cycle)
v. Vibration
vi. Bump
vii. Shock

Factory Acceptance Tests:

The supplier shall submit a test specification for factory acceptance test (FAT) and commissioning tests of the station automation system for approval. For the individual bay level IED's applicable type test certificates shall be submitted.

The manufacturing 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. If the FAT comprises only a certain portion of the system for practical reason, it has to be assured that this test configuration contains at least one unit of each and every type of equipment incorporated in the delivered system.
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).

Integrated Testing
The integrated system tests shall be performed as detailed in subsequent clauses as per following configuration:

- Redundant Station HMI, DR work station, two switches (i.e. for two diameter) along with all IEDs for the Dia and printers.

All other switches for complete sub-station shall be simulated as needed.

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.

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.

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

15.20. SYSTEM OPERATION

Substation Operation

NORMAL OPERATION
Operation of the system by the operator from the remote SLDC or at the substation shall take place via industry standard HMI (Human Machine interface) subsystem consisting of graphic colour VDU, a standard keyboard and a cursor positioning device (mouse). The coloured screen shall be divided into 4 fields :
i) Message field with display of present time and date
ii) Display field for single line diagrams
iii) Navigation bar with alarm/condition indication
iv) Real time bus energization status with distinguishable colours i.e. for live & dead section of SLD.
For display of alarm annunciation, lists of events etc a separate HMI View node. shall be provided.
All operations shall be performed with mouse and/or a minimum number of function keys and cursor keys. The function keys shall have different meanings depending on the

operation. The operator shall see the relevant meanings as function tests displayed in the command field (i.e. operator prompting). For control actions, the switchgear (i.e. circuit breaker etc.) requested shall be selectable on the display by means of the cursor keys. The switching element selected shall then appear on the background that shall be flashing in a different color. The operator prompting shall distinguish between:-
- Prompting of indications e.g. fault indications in the switchgear, and
- Prompting of operational sequences e.g. execution of switching operations

The summary information displayed in the message field shall give a rapid display of alarm/message of the system in which a fault has occurred and alarm annunciation lists in which the fault is described more fully.

Each operational sequence shall be divided into single operation steps which are initiated by means of the function keys/WINDOW command by mouse. Operator prompting shall be designed in such a manner that only the permissible keys are available in the command field related to the specific operation step. Only those switching elements shall be accessed for which control actions are possible. If the operation step is rejected by the system, the operator prompting shall be supported by additional comments in the message field. The operation status shall be reset to the corresponding preceding step in the operation sequence by pressing one of the function keys. All operations shall be verified. Incorrect operations shall be indicated by comments in the message field and must not be executed.

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

15.21. POWER SUPPLY

Power for the substation automation system shall be derived from substation 220/110V DC system.

Inverter of suitable capacity shall be provided for station HMI and its peripheral devices e.g. printer etc. In the event of Power failure, necessary safeguard software shall be built for proper shutdown and restart.

15.22. DOCUMENTATION

The following documents shall be submitted for employer’s approval during detailed engineering:

(a) System Architecture Drawing
(b) Hardware Specification
(c) Sizing Calculations of various components
(d) Response Time Calculation
(e) Functional Design Document
(f) Clear procedure describing how to add an IED/ bay in future covering all major suppliers

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 and also acrobat format.

- List of Drawings
- Substation Automation System Architecture
- Block Diagram
- Guaranteed Technical parameters, Functional Design Specification and Guaranteed availability and reliability
- Calculation for power supply dimensioning
- I/O Signal lists
- Schematic diagrams
- List of Apparatus
- List of Labels
- Logic Diagram (hardware & software)
- Control Room Lay-out
- Test Specification for Factory Acceptance Test (FAT)
- Product Technical Manuals

- Application Manuals
- Assembly Drawing
- Operator's Manual
- Testing and Commissioning Manuals
- Complete documentation of implemented protocols between various elements
- Listing of software and loadable in CD ROM
- Other documents as may be required during detailed engineering

Two sets of hard copy and Four sets of CD ROM containing all the as built documents/drawings shall be provided.

15.23. TRAINING, SUPPORT SERVICES, MAINTENANCE AND SPARES

Training at Contractor's Premises

The contractor shall arrange on its own cost all hardware and software training platform required for successful training and understanding in India. The Contractor shall provide all necessary training material. Each trainee shall receive individual copies of all technical manuals and all other documents used for training. These materials shall be sent to Employer at least two months before the scheduled commencement of the particular training course. Class materials, including the documents sent before the training courses as well as class handouts, shall become the property of Employer. Employer reserves the right to copy such materials, but for in-house training and use only. Hands-on training shall utilize equipment identical to that being supplied to Employer.

The contractor shall provide training comprehensively covering following courses.

S. No.	Name of Course	Participants from Employer	Duration
1	Computer System Hardware	2 per sub-station	7 day
2	Computer System Software	6 per sub-station	7 day
3	Application Software	2 per sub-station	7 day

A. Computer Hardware Course: The course will contain configuration of system hardware, equipment maintenance and diagnostic procedure of each element of the SAS including modems, routers, processors, technique for system expansion, and maintenance of IEDs. It will be a hand-on training.

B. Computer System Software Course: The course will cover programming language, OS software, network software, database software, system configuration, development of logic circuits. This will also be a hands-on training

C. Application Software: It will also a hands-on training and the course will contain application software and data flow, associated maintenance and expansion training, preparation and integration of new software etc.

Training offered shall be free of cost to the Employer except the logistic.

On Site Training:

After successful commissioning of the entire SAS, the contractor will impart on-site training in following areas:

S. No.	Name of Course	Participants from Employer	Duration
1	Computer System Hardware	2 per sub-station	7 day
2	Computer System Software	6 per sub-station	7 day
3	Application Software	2 per sub-station	7 day

Hands on training logic development, system configuration for extension of addition of bay, IED fault finding, trouble shooting, data analysis, changing of equipment parameters/ input data, preventive maintenance of each equipment

The site training will be also of similar nature as outlined in the previous clause, except that here the training will be on actual commissioned system and all aspects shall be covered. The training shall be conducted at each substation separately, covered in the package.

The Contractor shall submit the training modules for approval of the Employer. The training durations mentioned above is tentative only. Actual duration of the training shall be as per approved training module.

15.24. MAINTENANCE

Maintenance Responsibility during Pre-Commissioning and Commissioning Activities
During Pre-Commissioning and Commissioning activities, 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.

Maintenance Responsibility during Guarantee Period
During guarantee period as specified in tender document, contractor shall arrange bi-monthly visit of their representative to site to review the performance of system and in case any defect/shortcoming etc. is observed during the period, the same shall be set right by the contractor within 15 days free of any charge to the Employer.

15.25. RELIABILITY AND AVAILABILITY

The SAS shall be designed so that the failure of any single component, processor, or device shall not render the system unavailable. The SAS shall be designed to satisfy the very high demands for reliability and availability concerning:

- Mechanical and electrical design
- Security against electrical interference (EMI)
- High quality components and boards
- Modular, well-tested hardware
- Thoroughly developed and tested modular software
- Easy-to-understand programming language for application programming
- Detailed graphical documentation and application software
- Built-in supervision and diagnostic functions
- Security
- Experience of security requirements
- Process know-how
- Select before execute at operation
- Process status representation as double indications
- Distributed solution
- Independent units connected to the local area network
- Back-up functions
- Panel grounding immune against transient ground potential rise

Outage terms
1) Outage
The state in which substation automation system or a unit of SAS is unavailable for Normal Operation as defined in the clause above due to an event directly related to the SAS or unit of SAS. In the event, the Employer has taken any equipment/ system other than Sub-station Automation System for schedule/forced maintenance, the consequent outage to SAS shall not be considered as outage for the purpose of availability.

2) Actual outage duration (AOD)

The time elapsed in hours between the start and the end of an outage. The time shall be counted to the nearest 1/4th of an hour. Time less than 1/4th of an hour shall be counted as having duration of 1/4th of an hour.

3) Period Hours (PH)
The number of hours in the reporting period. In a full year the period hour are 8760h (8784h for a leap year).

4) Actual Outage hours (AOH)
The sum of actual outage duration within the reporting period AOH = Σ AOD

5) Availability
Each SAS shall have a total availability of 99.98 % i.e. the ratio of total time duration minus the actual outage duration to total time duration.

15.26. GUARANTEES REQUIRED
The availability for the complete SAS shall be guaranteed by the Contractor. Bidder shall include in their offer the detailed calculation for the availability. The contractor shall demonstrate their availability guaranteed by conducting the availability test on the total sub-station automation system as a whole during the pre-commissioning and commissioning periods. 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 700 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 700 Hours period start after such rectification. If test object has not been met the test shall continue until the specified availability is achieved.
The contractor has to establish the availability in a maximum period of three months from the date of commencement of the availability test.
After the satisfactory conclusion of test both contractor and employer shall mutually agree to the test results and if these results satisfy the availability criterion, the test is considered to be completed successfully. After that the system shall be taken over by the employer and then the guarantee period shall start along with the whole facilities.

15.27. SPARES
Consumables
All consumables such as paper, cartridges shall be supplied by the contractor till the SAS is taken over by the Employer.

Availability Spares:
In addition to mandatory spares as listed in below for SAS, the bidder is required to list the recommended spares along with unit prices, which may be required for ensuring the guaranteed availability of the system. During the entire guarantee period including the pre-commissioning and commissioning periods, the successful contractor will have to make available at site his recommended spares.
Based on the requirement of recommended spares during the entire guarantee period, the Employer will decide the final list of spares that the Employer will procure for safe running of the system after the guaranteed period. The contractor is bound to supply these spares promptly.

LIST OF MANDATORY SPARES
(a) FO cables with terminations for each type and length between IEDs (One FO cable for each type/length).
(b) Patch/Cu cable with terminations of each type and length between IEDs of Station level (One cable for each type/length)

(c) Any interface/Protocol converter (One for each type).
(d) BI/BO card for each type of IED (one no each).
(e) Power card for each type of IED (one no each).
(f) Transducers of each type (one no each)
(g) Industrial grade computer. (one number)

15.28. Major Component of SAS

Following minimum equipment shall comprise the Substation Automation System.

i) Station HMI & Redundant Station HMI (in Hot-stand by mode) of Latest Configuration and Latest OS Software with CD & DVD Multilayer Read, write, Rewrite with Possible all types of formats, Hard disk capacity of 1TB, Key Board, Optical Mouse, integrated VGA, Integrated LAN, 25" or More TFT Monitor (4:3 Screen).
ii) Engineering Station & Disturbance Recorder Work Station (Maintenance HMI)
iii) Gateways with PLCC/Fibre Optic Modem
iv) Required Inverter/UPS for 3 hour back up
v) List of Printers with / without Printer server
1. Colour Laser Printer– 1 No. (Print, Scan, Fax & Xerox) (For Reports & Disturbance records),
2. Line Printer - (For Alarms and Sequence of Event recorder)
3. Dot matrix printer Multi sheet paper Model – For log sheets, regular parameters at 15 min duration).
vi) All interface equipment for gateway to SLDC.
vii) Communication infrastructure between Bay level units, Station HMI, Printers, gateways, redundant LAN etc. as required. (Armoured FO and Cu Cables) as required.
viii) BCUs for Sub Station Auxiliaries.
ix) Any other equipment as necessary.

For all the SAS equipment, the power supply unit shall have dual mode i.e. main & redundant card, in case of any one card fail, the IED/Component of SAS shall have to switch over to redundant card and to generate alarm for the outage of the card.

All the type of cables used for LAN (Bay level & Station level) shall be Armoured type.

15.29. Erection, Testing & Commissioning

a) **The bidder shall depute their Engineer to the various sites for carrying out the testing and commissioning of C&R panel**.

15.30. GUARANTEES REQUIRED

The availability for the complete SAS shall be guaranteed by the Contractor.

The Guarantee period will be stipulated for 1 year and beyond which Annual Maintenance Contract (AMC) will come into force.

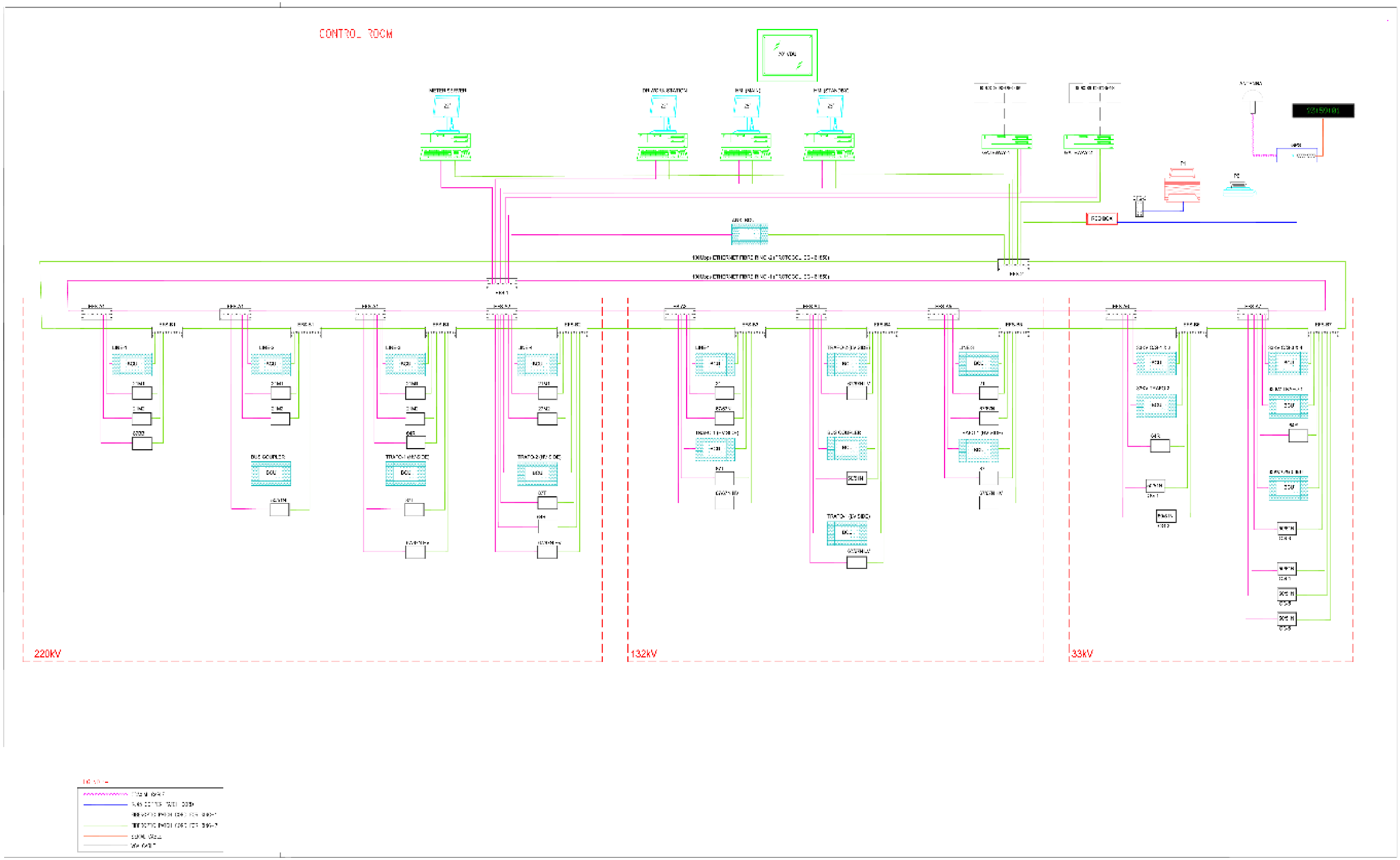
Bidder shall include in their offer the detailed calculation for the availability. The contractor shall demonstrate their availability guaranteed by conducting the availability test on the total sub-station automation system as a whole during the pre-commissioning and commissioning periods. The test 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 700 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 700 Hours period start after such rectification. If test object has not been met the test shall continue until the specified availability is achieved.

The contractor has to establish the availability in a maximum period of three months from the date of commencement of the availability test.

After the satisfactory conclusion of test both contractor and employer shall mutually agree to the test results and if these results satisfy the availability criterion, the test is considered to be completed successfully. After that the system shall be taken over by the employer and then the guarantee period shall start along with the whole facilities.

AMC shall be started after warranty period is over. During AMC, Manufacturer Engineer shall have to visit half yearly or as and when defects are developed. For any defects developed, Engineers are to attend the defects within three (3) working days of reporting. **The entire cost incurred for attending the issues raised/the regular yearly, half yearly visits shall be covered under the AMC. Manufacturer has the responsibility to take care of replacement of all items if required to restore the system**. During AMC, if any element is added up, integration of same is the responsibility of Manufacturer without any cost involvement to Employer.

ANNEXURE-I: SAS Architecture



Notes:

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 for control, protection & metering (ABT compliant electronic TVM) shall be installed in the swing type simplex C & R panels inside the control room, all connections shall be realized as per IEC 61850 protocol.

3) Required Inverter of Numeric make, 3 KVA capacity shall be provided by the bidder.

4) Necessary furniture for installation of complete equipment of SAS is also in the scope of supply. The successful bidder shall submit list of complete furniture including enclosure for printers.

5) For gateway, it shall communicate with Remote Control Centre and State Load Despatch Centre (SLDC) on IEC 60870-5-101 & 104 protocol.

6) The SLD displayed in the HMI shall be capable of distinguishing the Bus for different voltage level, bus live & dead status, bay equipment live & dead status and future extension indicating through different colours.

7) The printers shall be connected to station bus directly and can be managed from station HMI, as well as disturbance recorder work station.

The above Architecture is typical. The contractor is to consider the SLD of respective substation for detail BoQ, particularly for Ethernet Switches & BCUs.

ANNEXURE II

List of Analogue and Digital Inputs/ Outputs for SAS

1. **Basic Monitoring requirements are:**
   - o Switchgear status indication
   - o Measurements (U, I, P,MVA Q, f, sequence components, pf, phase angle, THD & TDD, Synchrocheck information i.e. ΔF, ΔV, Δφ; Active & Reactive energy)
   - o Event
   - o Alarm
   - o Winding temperature if transformers/ reactors
   - o Ambient temperature
   - o Status and display of station auxiliary ac & dc supply
   - o Status display of transformer fire protection system
   - o Acquisition of all counters in PLCC panels
   - o from PLCC or independently by counting the receive/send commands
   - o Acquisition of alarm and fault record from protection relays
   - o Disturbance records
   - o Monitoring the state of batteries by displaying DC voltage, charging current and load current etc for both 220/110-volt station & communication 48-volt batteries
   - o Tap-position of Transformer

2. List of Inputs: The list of input for typical bays is as below:-

1) **Analogue inputs**

➢ For line R, Y, B phase line currents & R-N, Y-N, B-N phase voltages

➢ For transformers □□R, Y, B phase line currents for HV & LV

- OTI & WTI
- Tap position

➢ For bus coupler R, Y, B phase line currents

➢ Common

- R-N, Y-N, B-N phase voltages for all buses
- Frequency of all buses
- Outside ambient temperature
- LT ac voltages
- 220/ 110-volt station battery voltage
- 48-volt battery voltage

2) Digital inputs

➢ Line bays

- Status of each pole of CB
- Status of isolator, earth switch
- CB trouble
- CB operation / closing lock out
- Pole discrepancy operated
- Trip circuit faulty
- LBB operated
- Bus bar protection trip operated
- Breaker auto reclosure operated
- Tie/ transfer breaker auto reclosure operated

- AR lock out
- Trip transfer sent/ received
- Main I / II DPR operated
- Directional E/F operated
- Fuse failure alarm
- PSB alarm
- Broken Conductor alarm
- Under voltage alarm
- SOTF trip
- Carrier aided trip
- Main I/ II Zone 2/ Zone III trip
- Back up O/C or E/F operated
- PLCC protection channel I/ II failed
- PLCC speech failed
- BCU/ BPU failed

➢ Transformer bays

- Status of CB, isolator, earth switch
- CB trouble
- CB operation/ closing lock out
- Pole discrepancy operated
- Trip circuit I/ II faulty
- BCU/ BPU failed
- LBB operated
- Bus bar protection operated
- REF operated
- Differential operated
- Over flux alarm/ trip
- OTI/ WTI alarm/ trip
- Buchholz alarm/ trip
- OLTC OSR trip
- Low oil alarm
- PRD I/ II operated
- Back up O/C or E/F operated
- Zero sequence current
- Discrimination of PT fuse fail and circuit dead

➢ Bus bar Protection

- Bus bar main I/ II trip
- Bus bar zone I/II open
- Bus protection relay fail
- BCU/ BPU failed

Other Signal to be incorporated in DR/SAS:

Standard DR Signal

1. **For transmission Line (One & half breaker scheme)**

	MAIN-1	-
A	**Configuration of ANALOG CHANNELS**	
S.No.	**Channel Description**	**Standardized Channel Name**
1	R Phase Current	I-R PH.
2	Y Phase Current	I-Y PH.
3	B Phase Current	I-B PH.
4	Neutral Current	I-N PH.
5	R Phase Voltage	V-R PH.
6	Y Phase Voltage	V-Y PH.
7	B Phase Voltage	V-B PH.
8	Open Delta Voltage	V-N (Open Delta)

B	**Configuration of Digital Channels for 32 channels**				
S.No.	**Channel Description**	**(Limited to 16 Characters)**	**7 characters**	**Triggers**	**COMMENTS**
1	MAIN CB R-PHASE OPEN	MAIN_CB_R_OPEN	M CB_RO	Y	
2	MAIN CB Y-PHASE OPEN	MAIN_CB_Y_OPEN	M CB_YO	Y	
3	MAIN CB B-PHASE OPEN	MAIN_CB_B_OPEN	M CB_BO	Y	
4	TIE CB R-PHASE OPEN	TIE_CB_R_OPEN	T CB_RO	Y	
5	TIE CB Y-PHASE OPEN	TIE_CB_Y_OPEN	T CB_YO	Y	
6	TIE CB B-PHASE OPEN	TIE_CB_B_OPEN	T CB_BO	Y	
7	MAIN1 TRIP	MAIN1_TRIP	M1_TRIP	Y	
8	MAIN2 TRIP	MAIN2_TRIP	M2_TRIP	Y	MAIN-2
9	AUTO RECLOSE OPTD MAIN CB	MAIN_CB_A/R_OPTD	M CB_AR	Y	
10	MAIN CB AR LOCKOUT	MAIN CB AR LO	MCB AR LO	N	
11	AUTO RECLOSE OPTD TIE	TIE_CB_A/R_OPTD	T CB_AR	Y	

B	Configuration of Digital Channels for 32 channels				
S.No.	Channel Description	(Limited to 16 Characters)	7 characters	Triggers	COMMENTS
	CB				
12	TIE CB AR LOCKOUT	TIE CB A/R_LO	AR_L/O	N	
13	MAIN1/2 CARRIER RECEIVE	MAIN1/2_CARR_REC	M1/2_CR	N	MAIN-1/2
14	DT RECEIVE CHANNEL-1/2	DT_REC_CH1/2	DTRC1/2	Y	
15	3 PH. GROUP A/B OPERATED	3PH_GR_A/B_OPTD	GRA/B_OPD	Y	
16	OVER VOLTAGE STAGE-1 OPERATED	O/V_STG1_OPTD	O/V_ST1	Y	
17	OVER VOLTAGE STAGE-2 OPERATED	O/V_STG2_OPTD	O/V_ST2	Y	
18	POWER SWING BLOCK OPERATED	PS BLK OPTD	PSB_OP	N	
19	STUB/TEED OPERATED	STUB_OPTD	SB_OPD	Y	Where ever Applicable
20	BUSBAR OPERATED (M1/M2)	BUSBAR_OPTD	BB_OPD	Y	
21	MAIN/TIE LBB OPERATED	M/T_LBB_OPTD	M/T_LBB	Y	
22	MAIN 1 ZONE-1 OPTD.	MAIN1_Z1_OPTD	M1Z1_OP	Y	
23	MAIN 1 ZONE-2 START	MAIN1_Z2_START	M1Z2_ST	N	
24	MAIN 1 ZONE-2 OPTD.	MAIN1_Z2_OPTD	M1Z2_OP	Y	
25	MAIN 1 ZONE-3 START	MAIN1_Z3_START	M1Z3_ST	N	
26	MAIN 1 ZONE-3 OPTD.	MAIN1_Z3_OPTD	M1Z3_OP	Y	
27	MAIN 1 REVERSE ZONE OPTD	MAIN1_ZR_OPTD	M1ZR_OP	Y	
28	MAIN 1/2 SOTF OPTD	M1/2_SOTF_OPD	M12SOTF	Y	
29	MAIN 1/2 DEF OPTD	DEF_OPD	DEF_OPD	Y	MAIN-1/2
30	MAIN1/2 CARR. SEND	M1/2 CARR. SEND	M12CRSD	N	MAIN-1/2
31	DIRECT TRIP SEND	DIR_TR SEND	DT_SEND	Y	
32	CARRIER AIDED TRIP	CARR_AID_TRIP	CAR_AID	Y	

	MAIN-2	
A	**Configuration of ANALOG CHANNELS**	
S.No	**Channel Description**	**Standardized Channel Name**
1	R Phase Current	I-R PH.
2	Y Phase Current	I-Y PH.
3	B Phase Current	I-B PH.
4	Neutral Current	I-N PH.
5	R Phase Voltage	V-R PH.
6	Y Phase Voltage	V-Y PH.
7	B Phase Voltage	V-B PH.
8	Open Delta Voltage	V-N (Open Delta)

B	**Configuration of Digital Channels for 32 channels**				
S.No.	**Channel Description**	**(Limited to 16 Characters)**	**7 characters**	**Triggers**	**COMMENTS**
1	MAIN CB R-PHASE OPEN	MAIN_CB_R_OPEN	M CB_RO	Y	
2	MAIN CB Y-PHASE OPEN	MAIN_CB_Y_OPEN	M CB_YO	Y	
3	MAIN CB B-PHASE OPEN	MAIN_CB_B_OPEN	M CB_BO	Y	
4	TIE CB R-PHASE OPEN	TIE_CB_R_OPEN	T CB_RO	Y	
5	TIE CB Y-PHASE OPEN	TIE_CB_Y_OPEN	T CB_YO	Y	
6	TIE CB B-PHASE OPEN	TIE_CB_B_OPEN	T CB_BO	Y	
7	MAIN1 TRIP	MAIN1_TRIP	M1_TRIP	Y	MAIN-1
8	MAIN2 TRIP	MAIN2_TRIP	M2_TRIP	Y	
9	MAIN 2 ZONE-1 OPTD.	MAIN2_Z1_OPTD	M2Z1_OP	Y	
10	MAIN 2 ZONE-2 START	MAIN2_Z2_START	M2Z2_ST	N	
11	MAIN 2 ZONE-2 OPTD.	MAIN2_Z2_OPTD	M2Z2_OP	Y	
12	MAIN 2 ZONE-3 START	MAIN2_Z3_START	M2Z3_ST	N	
13	MAIN 2 ZONE-3 OPTD.	MAIN2_Z3_OPTD	M2Z3_OP	Y	
14	MAIN 2 REVERSE ZONE START	MAIN2_ZR_START	M2ZR_ST	N	
15	MAIN 2 REVERSE ZONE	MAIN2_ZR_OPTD	M2ZR_OP	Y	

B	**Configuration of Digital Channels for 32 channels**				
S.No.	**Channel Description**	**(Limited to 16 Characters)**	**7 characters**	**Triggers**	**COMMENTS**
	OPTD				
16	POWER SWING DET.	PS_DETECTED	PS_DET	N	
17	POWER SWING BLOCK OPERATED	PS BLK OPTD	PSB_OP	N	
18	OVER VOLTAGE STAGE-1 OPERATED	O/V_STG1_OPTD	O/V_ST1	Y	
19	OVER VOLTAGE STAGE-2 OPERATED	O/V_STG2_OPTD	O/V_ST2	Y	
20	MAIN/TIE CB POLE DISCREPANCY	M/T_CB_POLE_DISC	M/T_PLDSC	N	
21	CARRIER AIDED TRIP	CAR_AID_TRP	CAR_TRP	Y	
22	MAIN-1 VT FUSE FAIL	VT_FUS_FAIL_M1	VT_FF_M1	N	MAIN-1
23	MAIN-2 VT FUSE FAIL	VT_FUS_FAIL_M2	VT_FF_M2	N	
24	MAIN-2 CARRIER RECEIVE	MAIN2_CARR_REC	M2_CR_RC	N	
25	OPTIONAL				
26	OPTIONAL				
27	OPTIONAL				
28	OPTIONAL				
29	OPTIONAL				
30	OPTIONAL				
31	OPTIONAL				
32	OPTIONAL				

	MAIN-1/2			
Configuration of Digital Channels for 16 channels				
S.No.	DIGITAL CHANNELS	(Limited to 16 Characters)	7 characters	Triggers
1	MAIN CB R-PHASE OPEN	MAIN_CB_R_OPEN	M CB_RO	Y
2	MAIN CB Y-PHASE OPEN	MAIN_CB_Y_OPEN	M CB_YO	Y

3	MAIN CB B-PHASE OPEN	MAIN_CB_B_OPEN	M CB_BO	Y
4	TIE CB R-PHASE OPEN	TIE_CB_R_OPEN	T CB_RO	Y
5	TIE CB Y-PHASE OPEN	TIE_CB_Y_OPEN	T CB_YO	Y
6	TIE CB B-PHASE OPEN	TIE_CB_B_OPEN	T CB_BO	Y
7	MAIN1 TRIP	MAIN1_TRIP	M1_TRIP	Y
8	MAIN2 TRIP	MAIN2_TRIP	M2_TRIP	Y
9	AUTO RECLOSE OPTD M/T CB	M/T_CB_A/R_OPTD	M/TCBAR	Y
10	MAIN1/2 CARRIER RECEIVE	MAIN1/2_CARR_REC	M1/2_CR	N
11	MAIN 1/2 DEF OPTD	DEF_OPD	DEF_OPD	Y
12	DT RECEIVE CHANNEL-1/2	DT_REC_CH-1/2	DTRC1/2	Y
13	OVER VOLTAGE STAGE-1/2 OPERATED	O/V_STG1/2_OPTD	OVST1/2	Y
14	STUB/TEED/SOTF OPERATED	ST_TEE_SOTF_OPTD	STF_OPD	Y
15	BUSBAR OPERATED (M1/M2)	BUSBAR_OPTD	BB_OPD	Y
16	MAIN/TIE CB LBB OPERATED	M/T_LBB_OPTD	M/T_LBB	Y

2. **DR for Transmission Line (Double Bus cum Transfer)**

Main 1

A	**Configuration of ANALOG CHANNELS**	
S.No.	**Channel Description**	**Standardized Channel Name**
1	R Phase Current	I-R PH.
2	Y Phase Current	I-Y PH.
3	B Phase Current	I-B PH.
4	Neutral Current	I-N PH
5	R Phase Voltage	V-R PH.
6	Y Phase Voltage	V-Y PH.
7	B Phase Voltage	V-B PH.
8	Open Delta Voltage	V-N-Open Delta

B	Configuration of Digital Channels for 32 channels				
S.No.	Channel Description	(Limited to 16 Characters)	7 characters	Triggers	COMMENTS
1	MAIN CB R-PHASE OPEN	MAIN_CB_R_OPEN	M CB_RO	Y	
2	MAIN CB Y-PHASE OPEN	MAIN_CB_Y_OPEN	M CB_YO	Y	
3	MAIN CB B-PHASE OPEN	MAIN_CB_B_OPEN	M CB_BO	Y	
4	TBC CB R-PHASE OPEN	TBC_CB_R_OPEN	T CB_RO	Y	
5	TBC CB Y-PHASE OPEN	TBC_CB_Y_OPEN	T CB_YO	Y	
6	TBC CB B-PHASE OPEN	TBC_CB_B_OPEN	T CB_BO	Y	
7	MAIN1 TRIP	MAIN1_TRIP	M1_TRIP	Y	
8	MAIN2 TRIP	MAIN2_TRIP	M2_TRIP	Y	MAIN-2
9	AUTO RECLOSE OPTD MAIN CB	MAIN_CB_A/R_OPTD	M CB_AR	Y	
10	MAIN CB AR LOCKOUT	MAIN CB AR LO	MCB AR LO	N	
11	AUTO RECLOSE OPTD TBC CB	TBC_CB_A/R_OPTD	T CB_AR	Y	
12	TBC CB AR LOCKOUT	TBC_CB_A/R_LO	AR_L/O	N	
13	MAIN1/2 CARRIER RECEIVE	MAIN1/2_CARR_REC	M1/2_CR	N	MAIN-1/2
14	DT RECEIVE CHANNEL-1/2	DT_REC_CH1/2	DTRC1/2	Y	
15	3 PH. GROUP A/B OPERATED	3PH_GR_A/B_OPTD	GRA/B_OPD	Y	
16	OVER VOLTAGE STAGE-1 OPERATED	O/V_STG1_OPTD	O/V_ST1	Y	
17	OVER VOLTAGE STAGE-2 OPERATED	O/V_STG2_OPTD	O/V_ST2	Y	
18	POWER SWING BLOCK OPERATED	PS BLK OPTD	PSB_OP	N	
19	MAIN-1 VT FUSE FAIL	VT_FUS_FAIL_M1	VT_FF_M1	N	
20	BUSBAR OPERATED (M1/M2)	BUSBAR_OPTD	BB_OPD	Y	
21	MAIN/TBC LBB OPERATED	M/T_LBB_OPTD	M/T_LBB	Y	
22	MAIN 1 ZONE-1 OPTD.	MAIN1_Z1_OPTD	M1Z1_OP	Y	

23	MAIN 1 ZONE-2 START	MAIN1_Z2_START	M1Z2_ST	N	
24	MAIN 1 ZONE-2 OPTD.	MAIN1_Z2_OPTD	M1Z2_OP	Y	
25	MAIN 1 ZONE-3 START	MAIN1_Z3_START	M1Z3_ST	N	
26	MAIN 1 ZONE-3 OPTD.	MAIN1_Z3_OPTD	M1Z3_OP	Y	
27	MAIN 1 REVERSE ZONE OPTD	MAIN1_ZR_OPTD	M1ZR_OP	Y	
28	MAIN 1/2 SOTF OPTD	M1/2_SOTF_OPD	M12SOTF	Y	
29	MAIN 1/2 DEF OPTD	DEF_OPD	DEF_OPD	Y	MAIN-1/2
30	MAIN1/2 CARR. SEND	M1/2 CARR. SEND	M12CRSD	N	MAIN-1/2
31	DIRECT TRIP SEND	DIR_TR SEND	DT_SEND	Y	
32	CARRIER AIDED TRIP	CARR_AID_TRIP	CAR_AID	Y	

	MAIN-2	
A	**Configuration of ANALOG CHANNELS**	
S.No.	**Channel Description**	**Standardized Channel Name**
1	R Phase Current	I-R PH.
2	Y Phase Current	I-Y PH.
3	B Phase Current	I-B PH.
4	Neutral Current	I-N PH.
5	R Phase Voltage	V-R PH.
6	Y Phase Voltage	V-Y PH.
7	B Phase Voltage	V-B PH.
8	Open Delta Voltage	V-N (Open Delta)

B	**Configuration of Digital Channels for 32 channels**				
S.No.	**Channel Description**	**(Limited to 16 Characters)**	**7 characters**	**Triggers**	**COMMENTS**
1	MAIN CB R-PHASE OPEN	MAIN_CB_R_OPEN	M CB_RO	Y	
2	MAIN CB Y-PHASE OPEN	MAIN_CB_Y_OPEN	M CB_YO	Y	
3	MAIN CB B-PHASE OPEN	MAIN_CB_B_OPEN	M CB_BO	Y	
4	TBC CB R-PHASE OPEN	TBC_CB_R_OPEN	T CB_RO	Y	
5	TBC CB Y-PHASE OPEN	TBC_CB_Y_OPEN	T CB_YO	Y	

B	Configuration of Digital Channels for 32 channels				
S.No.	Channel Description	(Limited to 16 Characters)	7 characters	Triggers	COMMENTS
6	TBC CB B-PHASE OPEN	TIE_CB_B_OPEN	T CB_BO	Y	
7	MAIN1 TRIP	MAIN1_TRIP	M1_TRIP	Y	MAIN-1
8	MAIN2 TRIP	MAIN2_TRIP	M2_TRIP	Y	
9	MAIN 2 ZONE-1 OPTD.	MAIN2_Z1_OPTD	M2Z1_OP	Y	
10	MAIN 2 ZONE-2 START	MAIN2_Z2_START	M2Z2_ST	N	
11	MAIN 2 ZONE-2 OPTD.	MAIN2_Z2_OPTD	M2Z2_OP	Y	
12	MAIN 2 ZONE-3 START	MAIN2_Z3_START	M2Z3_ST	N	
13	MAIN 2 ZONE-3 OPTD.	MAIN2_Z3_OPTD	M2Z3_OP	Y	
14	MAIN 2 REVERSE ZONE START	MAIN2_ZR_START	M2ZR_ST	N	
15	MAIN 2 REVERSE ZONE OPTD	MAIN2_ZR_OPTD	M2ZR_OP	Y	
16	POWER SWING DET.	PS_DETECTED	PS_DET	N	
17	POWER SWING BLOCK OPERATED	PS BLK OPTD	PSB_OP	N	
18	OVER VOLTAGE STAGE-1 OPERATED	O/V_STG1_OPTD	O/V_ST1	Y	
19	OVER VOLTAGE STAGE-2 OPERATED	O/V_STG2_OPTD	O/V_ST2	Y	
20	MAIN/TBC CB POLE DISCREPANCY	M/T_CB_POLE_DISC	M/T_PLDSC	N	
21	CARRIER AIDED TRIP	CAR_AID_TRP	CAR_TRP	Y	
22	DIRECT TRIP SEND	DIR_TR SEND	DT_SEND	Y	
23	MAIN-2 VT FUSE FAIL	VT_FUS_FAIL_M2	VT_FF_M2	N	
24	MAIN-2 CARRIER RECEIVE	MAIN2_CARR_REC	M2_CR_RC	N	
25	OPTIONAL				
26	OPTIONAL				
27	OPTIONAL				
28	OPTIONAL				
29	OPTIONAL				

B	Configuration of Digital Channels for 32 channels				
S.No.	Channel Description	(Limited to 16 Characters)	7 characters	Triggers	COMMENTS
30	OPTIONAL				
31	OPTIONAL				
32	OPTIONAL				

Configuration of Digital Channels for 16 channels				
S.No.	DIGITAL CHANNELS	(Limited to 16 Characters)	7 characters	Triggers
1	MAIN CB R-PHASE OPEN	MAIN_CB_R_OPEN	M CB_RO	Y
2	MAIN CB Y-PHASE OPEN	MAIN_CB_Y_OPEN	M CB_YO	Y
3	MAIN CB B-PHASE OPEN	MAIN_CB_B_OPEN	M CB_BO	Y
4	TBC CB R-PHASE OPEN	TBC_CB_R_OPEN	T CB_RO	Y
5	TBC CB Y-PHASE OPEN	TBC_CB_Y_OPEN	T CB_YO	Y
6	TBC CB B-PHASE OPEN	TBC_CB_B_OPEN	T CB_BO	Y
7	MAIN1 TRIP	MAIN1_TRIP	M1_TRIP	Y
8	MAIN2 TRIP	MAIN2_TRIP	M2_TRIP	Y
9	AUTO RECLOSE OPTD M/T CB	M/T_CB_A/R_OPTD	M/TCBAR	Y
10	MAIN1/2 CARRIER RECEIVE	MAIN1/2_CARR_REC	M1/2_CR	N
11	MAIN 1/2 DEF OPTD	DEF_OPD	DEF_OPD	Y
12	DT RECEIVE CHANNEL-1/2	DT_REC_CH-1/2	DTRC1/2	Y
13	OVER VOLTAGE STAGE-1/2 OPERATED	O/V_STG1/2_OPTD	OVST1/2	Y
14	SOTF OPERATED	SOTF_OPTD	STF_OPD	Y
15	BUSBAR OPERATED (M1/M2)	BUSBAR_OPTD	BB_OPD	Y
16	MAIN/TBC CB LBB OPERATED	M/T_LBB_OPTD	M/T_LBB	Y

3. DR for Transformer (one and half breaker scheme)

A	Configuration of ANALOG CHANNELS		
S.No.	Channel Description	Standardized	COMMENTS

		Channel Name	
1	HV R Phase Current	I-R PH. HV	
2	HV Y Phase Current	I-Y PH. HV	
3	HV B Phase Current	I-B PH. HV	
4	HV Neutral Current	I-N HV	
5	IV R Phase Current	I-R PH. IV	
6	IV Y Phase Current	I-Y PH. IV	
7	IV B Phase Current	I-B PH. IV	
9	IV Neutral Current	I-N IV	
10	R Phase DIFFERENTIAL Current (CALCULATED)	IR DIFF	
11	Y Phase DIFFERENTIAL Current (CALCULATED)	IY DIFF	
12	B Phase DIFFERENTIAL Current (CALCULATED)	IB DIFF	
13	LV R Phase Current	L-R PH. IV	OPTIONAL
14	LV Y Phase Current	L-Y PH. IV	OPTIONAL
15	LV B Phase Current	L-B PH. IV	OPTIONAL
16	LV Neutral Current	L-N IV	OPTIONAL
17	HV R Ph Voltage	V-R PH HV	OPTIONAL
18	HV Y Ph Voltage	V-Y PH HV	OPTIONAL
19	HV B Ph Voltage	V-B PH HV	OPTIONAL

B	**Configuration of Digital Channels for 32 channels**				
S.No.	**Channel Description**	**(Limited to 16 Characters)**	**7 characters**	**Triggers**	**COMMENTS**
1	MAIN CB OPEN (HV SIDE)	HV_M_CB_OPEN	HV_MCBO	Y	
2	TIE CB OPEN (HV SIDE)	HV_T_CB_OPEN	HV_TCBO	Y	
3	MAIN CB OPEN (IV SIDE)	IV_M_CB_OPEN	IV_MCBO	Y	
4	TIE/TBC CB OPEN (IV SIDE)	IV_T_CB_OPEN	IV_TCBO	Y	
5	DIFFERENTIAL PROTECTION OPERATED	DIFF_PROTN_OPTD	DIF_OPD	Y	
6	REF PROTECTION OPERATED	REF_PROTN_OPTD	REF_OPD	Y	
7	HV OC PROTECTION	HV_B/U_PROTN_OPD	HVBUOPD	Y	

	OPERATED				
8	HV EF PROTN OPERATED	HV_EF_PROTN_OPD	HVEFOPD	Y	
9	HV OVER FLUXING OPERATED	HV_OVERFLUX_OPTD	HVOFOPD	Y	
10	IV OVER FLUXING OPERATED	IV_OVERFLUX_OPTD	IVOFOPD	Y	
11	PRV TRIP	PRV_TRIP	PRV_TRP	Y	
12	WTI TRIP	WTI_TRIP	WTI_TR	Y	HV/IV/LV
13	OSR TRIP	OSR_TRIP	OSR_TRP	Y	
14	OTI TRIP	OTI_TRIP	OTI_TRP	Y	
15	BUCHHOLZ TRIP	BUCHHOLZ_TRIP	BCZ_TRP	Y	
16	3 PH. GROUP A OPERATED	3PH_GR_A_OPTD	GRA_OPD	Y	
17	3 PH. GROUP B OPERATED	3PH_GR_B_OPTD	GRB_OPD	Y	
18	MAIN CB (HV SIDE) LBB OPTD.	HV_MAIN_LBB_OPTD	H_M_LBB	Y	
19	MAIN CB (IV SIDE) LBB OPTD.	IV_MAIN_LBB_OPTD	I_M_LBB	Y	
20	TIE CB (HV SIDE) LBB OPTD.	HV_TIE_LBB_OPTD	H_T_LBB	Y	
21	TIE/TBC CB (IV SIDE) LBB OPTD.	IV_T_LBB_OPTD	I_T_LBB	Y	
22	BUSBAR OPERATED	BUSBAR_OPTD	BB_OPD	Y	
23	DTOC OPTD	DTOC_OPTD	DTOCOPD	Y	IF APPLICABLE
24	OLTC OIL SURGE TRIP	OLTC_OIL SGTR	OL_SR_TR	Y	
25	HV VT FUSE FAIL ALARM	HVVT_FUS_FAIL	HVVT_FF	N	
26	WTI ALARM	WTI_ALARM	WTI_AL	N	HV/IV/LV
27	OTI ALARM	OTI_ALARM	OTI_AL	N	
28	OVER LOAD ALARM	OL_ALARM	OL_AL	N	
29					OPTIONAL
30					OPTIONAL
31					OPTIONAL
32					OPTIONAL

Configuration of Digital Channels for 16 channels				
S.No.	**DIGITAL CHANNELS**	**(Limited to 16 Characters)**	**7 characters**	**Triggers**

1	MAIN CB OPEN (HV SIDE)	HV_M_CB_OPEN	HV_MCBO	Y
2	TIE CB OPEN (HV SIDE)	HV_T_CB_OPEN	HV_TCBO	Y
3	MAIN CB OPEN (IV SIDE)	IV_M_CB_OPEN	IV_MCBO	Y
4	TBC/TIE CB OPEN (IV SIDE)	IV_T_CB_OPEN	IV_TCBO	Y
5	DIFFERENTIAL PROTECTION OPERATED	DIFF_PROTN_OPTD	DIF_OPD	Y
6	REF PROTECTION OPERATED	REF_PROTN_OPTD	REF_OPD	Y
7	HV BACKUP PROTECTION OPERATED	HV_B/U_PROTN_OPD	HVBUOPD	Y
8	HV/IV OVER FLUXING OPERATED	HV/IV_O/F_OPD	O/F_OPD	Y
9	PRV TRIP	PRV_TRIP	PRV_TRP	Y
10	OTI/WTI TRIP	OTI/WTI_TRIP	OT/WT_T	Y
11	BUCHHOLZ/OSR TRIP	BUCH/OSR_TRIP	B_OSR_T	Y
12	MAIN/TIE CB (HV SIDE) LBB OPTD.	M/T_HV_LBB	HV_LBB	Y
13	MAIN/TBC CB (IV SIDE) LBB OPTD.	M/T_IV_LBB	IV_LBB	Y
14	BUSBAR OPERATED	BUSBAR_OPTD	BB_OPD	Y
15	DTOC OPTD	DTOC_OPTD	DTOCOPD	Y
16	3 PH. GROUP A/B OPERATED	3PH_GR_A/B_OPTD	GRA/B_OPD	Y

4. **DR for Bus/Line Reactor for one and half breaker scheme**
   a. For back up Impedance Relay

A	**Configuration of ANALOG CHANNELS**		
S.No.	Channel Description	Standardized Channel Name	COMMENTS
1	R Phase Current	I-R PH.	
2	Y Phase Current	I-Y PH.	
3	B Phase Current	I-B PH.	
4	Neutral Current	I-N PH.	

5	R Phase Voltage	V-R PH.	
6	Y Phase Voltage	V-Y PH.	
7	B Phase Voltage	V-B PH.	
8	Neutral voltage	V-N PH.	

B	**Configuration of Digital Channels for 32 channels**			
S.No.	**Channel Description**	**(Limited to 16 Characters)**	**7 characters**	**Triggers**
1	MAIN CB OPEN	MAIN_CB_OPEN	M_CB_O	Y
2	TIE CB OPEN	TIE_CB_OPEN	T_CB_O	Y
3	DIFFERENTIAL PROTECTION OPERATED	DIFF_PROTN_OPTD	DIF_OPD	Y
4	REF PROTECTION OPERATED	REF_PROTN_OPTD	REF_OPD	Y
5	BACKUP IMPEDANCE PROTN OPERATED	BU_IMP_PROTN_OPD	BUIMPOP	Y
6	PRV TRIP	PRV_TRIP	PRV_TRP	Y
7	WTI TRIP	WTI_TRIP	WTI_TRP	Y
8	WTI ALARM	WTI_ALARM	WTI_AL	Y
9	OTI TRIP	OTI_TRIP	OTI_TRP	Y
10	OTI ALARM	OTI_ALARM	OTI_AL	Y
11	BUCHHHOLZ TRIP	BUCHHHOLZ_TRIP	BCZ_TRP	Y
12	BUCHHHOLZ ALARM	BUCHHHOLZ_ALARM	BCZ_AL	Y
13	MAIN LBB OPERATED	MAIN_LBB_OPD	MLBBOPD	Y
14	TIE LBB OPERATED	TIE_LBB_OPD	TLBBOPD	Y
15	BUS BAR OPERATED	BUSBAR_OPTD	BB_OPD	Y
16	3 PH. GROUP A OPERATED	3PH_GR_A_OPTD	GRA_OPD	Y
17	3 PH. GROUP B OPERATED	3PH_GR_B_OPTD	GRB_OPD	Y
18	NGR PROTECTION OPERATED	NGR_PROTN_OPTD	NGR_OPD	Y
19	TEED PROTECTION OPERATED	TEED_PROTN_OPTD	TEE_OPD	Y
20	VT FUSE FAIL ALARM	VT_FUS_FAIL	VT_FF	N

B	Configuration of Digital Channels for 16 channels			
S.No.	**Channel Description**	**(Limited to 16 Characters)**	**7 characters**	**Triggers**
1	MAIN CB OPEN	MAIN_CB_OPEN	M_CB_O	Y
2	TIE CB OPEN	TIE_CB_OPEN	T_CB_O	Y
3	DIFFERENTIAL PROTECTION OPERATED	DIFF_PROTN_OPTD	DIF_OPD	Y
4	REF PROTECTION OPERATED	REF_PROTN_OPTD	REF_OPD	Y
5	BACKUP IMPEDANCE PROTN OPERATED	BU_IMP_PROTN_OPD	BUIMPOP	Y
6	PRV TRIP	PRV_TRIP	PRV_TRP	Y
7	WTI TRIP	WTI_TRIP	WTI_TRP	Y
8	TEED PROTECTION OPERATED	TEED_PROTN_OPTD	TEE_OPD	Y
9	OTI TRIP	OTI_TRIP	OTI_TRP	Y
10	BUCHHHOLZ TRIP	BUCHHHOLZ_TRIP	BCZ_TRP	Y
11	MAIN LBB OPERATED	MAIN_LBB_OPD	MLBBOPD	Y
12	TIE LBB OPERATED	TIE_LBB_OPD	TLBBOPD	Y
13	BUS BAR OPERATED	BUSBAR_OPTD	BB_OPD	Y
14	3 PH. GROUP A OPERATED	3PH_GR_A_OPTD	GRA_OPD	Y
15	3 PH. GROUP B OPERATED	3PH_GR_B_OPTD	GRB_OPD	Y
16	NGR PROTECTION OPERATED	NGR_PROTN_OPTD	NGR_OPD	Y

b. For Main Differential Relay

A	Configuration of ANALOG CHANNELS	
S.No.	**Channel Description**	**Standardized Channel Name**
1	R Phase Current	I-R PH.
2	Y Phase Current	I-Y PH.
3	B Phase Current	I-B PH.
4	Neutral Current	I-N PH.
5	R Phase Current NEUTRAL SIDE	I-RN PH.
6	Y Phase Current NEUTRAL SIDE	I-YN PH.

7	B Phase Current NEUTRAL SIDE	I-BN PH.
8	R Phase DIFFERENTIAL Current (CALCULATED)	IR DIFF
9	Y Phase DIFFERENTIAL Current (CALCULATED)	IY DIFF
10	B Phase DIFFERENTIAL Current (CALCULATED)	IB DIFF

B	**Configuration of Digital Channels for 32 channels**			
S.No.	**Channel Description**	**(Limited to 16 Characters)**	**7 characters**	**Triggers**
1	MAIN CB OPEN	MAIN_CB_OPEN	M_CB_O	Y
2	TIE CB OPEN	TIE_CB_OPEN	T_CB_O	Y
3	DIFFERENTIAL PROTECTION OPERATED	DIFF_PROTN_OPTD	DIF_OPD	Y
4	REF PROTECTION OPERATED	REF_PROTN_OPTD	REF_OPD	Y
5	BACKUP IMPEDANCE PROTN OPERATED	BU_IMP_PROTN_OPD	BUIMPOP	Y
6	PRV TRIP	PRV_TRIP	PRV_TRP	Y
7	WTI TRIP	WTI_TRIP	WTI_TRP	Y
8	WTI ALARM	WTI_ALARM	WTI_AL	Y
9	OTI TRIP	OTI_TRIP	OTI_TRP	Y
10	OTI ALARM	OTI_ALARM	OTI_AL	Y
11	BUCHHHOLZ TRIP	BUCHHHOLZ_TRIP	BCZ_TRP	Y
12	BUCHHHOLZ ALARM	BUCHHHOLZ_ALARM	BCZ_AL	Y
13	MAIN LBB OPERATED	MAIN_LBB_OPD	MLBBOPD	Y
14	TIE LBB OPERATED	TIE_LBB_OPD	TLBBOPD	Y
15	BUS BAR OPERATED	BUSBAR_OPTD	BB_OPD	Y
16	3 PH. GROUP A OPERATED	3PH_GR_A_OPTD	GRA_OPD	Y
17	3 PH. GROUP B OPERATED	3PH_GR_B_OPTD	GRB_OPD	Y
18	NGR PROTECTION OPERATED	NGR_PROTN_OPTD	NGR_OPD	Y
19	TEED PROTECTION OPERATED	TEED_PROTN_OPTD	TEE_OPD	Y

B	Configuration of Digital Channels for 16 channels			
S.No.	Channel Description	(Limited to 16 Characters)	7 characters	Triggers
1	MAIN CB OPEN	MAIN_CB_OPEN	M_CB_O	Y
2	TIE CB OPEN	TIE_CB_OPEN	T_CB_O	Y
3	DIFFERENTIAL PROTECTION OPERATED	DIFF_PROTN_OPTD	DIF_OPD	Y
4	REF PROTECTION OPERATED	REF_PROTN_OPTD	REF_OPD	Y
5	BACKUP IMPEDANCE PROTN OPERATED	BU_IMP_PROTN_OPD	BUIMPOP	Y
6	PRV TRIP	PRV_TRIP	PRV_TRP	Y
7	WTI TRIP	WTI_TRIP	WTI_TRP	Y
8	TEED PROTECTION OPERATED	TEED_PROTN_OPTD	TEE_OPD	Y
9	OTI TRIP	OTI_TRIP	OTI_TRP	Y
10	BUCHHHOLZ TRIP	BUCHHHOLZ_TRIP	BCZ_TRP	Y
11	MAIN LBB OPERATED	MAIN_LBB_OPD	MLBBOPD	Y
12	TIE LBB OPERATED	TIE_LBB_OPD	TLBBOPD	Y
13	BUS BAR OPERATED	BUSBAR_OPTD	BB_OPD	Y
14	3 PH. GROUP A OPERATED	3PH_GR_A_OPTD	GRA_OPD	Y
15	3 PH. GROUP B OPERATED	3PH_GR_B_OPTD	GRB_OPD	Y
16	NGR PROTECTION OPERATED	NGR_PROTN_OPTD	NGR_OPD	Y

5. Standard list of Sequence of Events (SOE)

SCADA SIGNAL LIST FOR VARIOUS PROTECTION & CONTROL SIGNALS

REQUIRED SIGNALS FOR DISTANCE RELAYS			
SL. NO.	TYPE	EVENT/ALARM NAME	WHETHER ALARM TO BE GENERATED
1	SPI	OVERVOLATGE STAGE 1 START	
2	SPI	OVERVOLATGE STAGE 1 GEN TRIP	Y
3	SPI	OVERVOLATGE STAGE 2 GEN	Y

		TRIP	
4	SPI	DEF START	
5	SPI	DEF GEN TRIP	Y
6	SPI	STUB PROTECTION OPERATED	Y
7	SPI	SOTF OPERATED	Y
8	SPI	START, Z1 R PH	
9	SPI	START, Z1 Y PH	
10	SPI	START, Z1 B PH	
11	SPI	START, Z2	
12	SPI	START, Z3	
13	SPI	START, Z4	
14	SPI	START, Z5	
15	SPI	TRIP, Z1 R PH	Y
16	SPI	TRIP, Z1 Y PH	Y
17	SPI	TRIP, Z1 B PH	Y
18	SPI	GENERAL TRIP, Z2	Y
19	SPI	GENERAL TRIP, Z3	Y
20	SPI	GENERAL TRIP, Z4	Y
21	SPI	GENERAL TRIP, Z5	Y
22	SPI	CARRIER SEND	Y
23	SPI	CARRIER RECEIVE	Y
24	SPI	CARRIER AIDED SCHEME OPERATED	Y
25	SPI	POWER SWING DETECTED	Y
26	SPI	POWER SWING BLOCKING	Y
27	SPI	DISTANCE RELAY GENERAL TRIP	Y
28	DINT	FAULT LOCATOR DISTANCE	
29	SPI	CVT FUSE FAIL	Y
30	System Diagnosis (SON)	TIME SYNCHRONIZATION ERROR	Y

31	System Diagnosis (SON)	M1 IED UNHEALTHY	Y
32	SPI	START AR	
33	SPI	LINE ISOLATOR OPEN FOR STUB ACTIVATION	
34	SPI	DT SEND CH 1	Y
35	SPI	DT SEND CH 1	Y
36	SPI	DT RECEIVE CH 1	Y
37	SPI	DT RECEIVE CH 2	Y
38	SPI	MAIN CB R PH OPEN	
39	SPI	MAIN CB Y PH OPEN	
40	SPI	MAIN CB B PH OPEN	
41	SPI	TIE CB R PH OPEN	
42	SPI	TIE CB Y PH OPEN	
43	SPI	TIE CB B PH OPEN	
44	SPI	TRIP RELAY 86 A HEALTHY (SUPERVISION)	
45	SPI	TRIP RELAY 86 B HEALTHY (SUPERVISION)	
46	SPI	GR A RELAY OPERATED	Y
47	SPI	GR B RELAY OPERATED	Y
48	SPI	CARRIER CHANNEL 1/2 OUT OF SERVICE	Y
49	SPI	CARRIER CHANNEL 1 FAIL	Y
50	SPI	CARRIER CHANNEL 2 FAIL	Y
51	SPI	MAIN 2/1 RELAY FAIL	Y
52	SPI	GOOSE RECEIPT FAIL/TROUBLE	Y
53		**ANY ADDITIONAL SIGNAL AS PER SCHEME**	

REQUIRED SIGNALS FOR ICT DIFFERENTIAL RELAYS			
SL. NO.	**TYPE**	**EVENT/ALARM NAME**	**WHETHER ALARM TO BE GENERATED**

REQUIRED SIGNALS FOR ICT DIFFERENTIAL RELAYS			
SL. NO.	**TYPE**	**EVENT/ALARM NAME**	**WHETHER ALARM TO BE GENERATED**
1	SPI	OVEREXCITATION HV START	
2	SPI	OVEREXCITATION HV ALARM	Y
3	SPI	OVEREXCITATION HV TRIP	Y
4	SPI	DIFFERENTIAL CURRENT ALARM	Y
5	SPI	DIFFERENTIAL PROTECTION TRIP	Y
6	INT	RESTRAINED MODE (RESTRAINED OR UNRESTRAINED)	
7	SPI	GENERAL TRIP	Y
8	System Diagnosis (SON)	TIME SYNCHRONIZATION ERROR	Y
9	System Diagnosis (SON)	DIFFRENTIAL IED UNHEALTHY	Y
10	SPI	DIFFERENTIAL RELAY GENERAL TRIP	Y
11	SPI	OTI ALARM	Y
12	SPI	WTI HV ALARM	Y
13	SPI	WTI IV ALARM	Y
14	SPI	WTI MV ALARM	Y
15	SPI	BUCCHOLZ TRIP	Y
16	SPI	OSR 1 TRIP	Y
17	SPI	PRD 1 TRIP	Y
18	SPI	FIRE PROTECTION OPERATED	Y
19	SPI	LOW OIL LEVEL	Y
20	SPI	OTI R PH ALARM	Y
21	SPI	OTI Y PH ALARM	Y
22	SPI	OTI B PH ALARM	Y
23	SPI	OTI SPARE ICT ALARM	Y

REQUIRED SIGNALS FOR ICT DIFFERENTIAL RELAYS			
SL. NO.	TYPE	EVENT/ALARM NAME	WHETHER ALARM TO BE GENERATED
24	SPI	WTI HV R PH ALARM	Y
25	SPI	WTI HV Y PH ALARM	Y
26	SPI	WTI HV B PH ALARM	Y
27	SPI	WTI HV SPARE ICT ALARM	Y
28	SPI	WTI MV R PH ALARM	Y
29	SPI	WTI MV Y PH ALARM	Y
30	SPI	WTI MV B PH ALARM	Y
31	SPI	WTI MV SPARE ICT ALARM	Y
32	SPI	WTI IV R PH ALARM	Y
33	SPI	WTI IV Y PH ALARM	Y
34	SPI	WTI IV B PH ALARM	Y
35	SPI	WTI IV SPARE ICT ALARM	Y
36	SPI	BUCCHOLZ R PH TRIP	Y
37	SPI	BUCCHOLZ Y PH TRIP	Y
38	SPI	BUCCHOLZ B PH TRIP	Y
39	SPI	BUCCHOLZ SPARE ICT TRIP	Y
40	SPI	OSR 1 R PH TRIP	Y
41	SPI	OSR 1 Y PH TRIP	Y
42	SPI	OSR 1 B PH TRIP	Y
43	SPI	OSR 1 SPARE ICT TRIP	Y
44	SPI	PRD 1 R PH TRIP	Y
45	SPI	PRD 1 Y PH TRIP	Y
46	SPI	PRD 1 B PH TRIP	Y
47	SPI	LOW OIL LEVEL R PH	Y
48	SPI	LOW OIL LEVEL Y PH	Y
49	SPI	LOW OIL LEVEL B PH	Y
50	SPI	LOW OIL LEVEL SPARE ICT	Y
51	SPI	FIRE PROTECTION R PH OPERATED	Y

REQUIRED SIGNALS FOR ICT DIFFERENTIAL RELAYS			
SL. NO.	**TYPE**	**EVENT/ALARM NAME**	**WHETHER ALARM TO BE GENERATED**
52	SPI	FIRE PROTECTION Y PH OPERATED	Y
53	SPI	FIRE PROTECTION B PH OPERATED	Y
54	SPI	FIRE PROTECTION SPARE ICT OPERATED	Y
55	SPI	MAIN CB R PH OPEN	
56	SPI	MAIN CB Y PH OPEN	
57	SPI	MAIN CB B PH OPEN	
58	SPI	TIE CB R PH OPEN	
59	SPI	TIE CB Y PH OPEN	
60	SPI	TIE CB B PH OPEN	
61	SPI	TRIP RELAY 86 A HEALTHY (SUPERVISION)	Y
62	SPI	TRIP RELAY 86 B HEALTHY (SUPERVISION)	Y
63	SPI	GR A RELAY OPERATED	Y
64	SPI	GR B RELAY OPERATED	Y
65	SPI	REF RELAY FAIL	Y
66	SPI	GOOSE RECEIPT FAIL/TROUBLE	Y
67	SPI	**ANY ADDITIONAL SIGNAL AS PER SCHEME**	

REQUIRED SIGNALS FOR ICT REF RELAYS			
SL. NO.	**TYPE**	**EVENT/ALARM NAME**	**WHETHER ALARM TO BE GENERATED**
1	SPI	OVEREXCITATION MV START	
2	SPI	OVEREXCITATION MV ALARM	Y
3	SPI	OVEREXCITATION MV TRIP	Y

REQUIRED SIGNALS FOR ICT REF RELAYS			
SL. NO.	**TYPE**	**EVENT/ALARM NAME**	**WHETHER ALARM TO BE GENERATED**
4	System Diagnosis (SON)	TIME SYNCHRONIZATION ERROR	Y
5	System Diagnosis (SON)	DIFFRENTIAL IED UNHEALTHY	Y
6	SPI	REF RELAY ALARM	Y
7	SPI	REF TRIP	Y
8	SPI	GENERAL TRIP	Y
9	SPI	REF TRIP	Y
10	SPI	OTI TRIP	Y
11	SPI	WTI HV TRIP	Y
12	SPI	WTI MV TRIP	Y
13	SPI	WTI LV TRIP	Y
14	SPI	OSR 2 TRIP	Y
15	SPI	PRD 2 TRIP	Y
16	SPI	BUCCHOLZ ALARM	Y
17	SPI	OTI R PH TRIP	Y
18	SPI	OTI Y PH TRIP	Y
19	SPI	OTI B PH TRIP	Y
20	SPI	OTI SPARE ICT TRIP	Y
21	SPI	WTI HV R PH TRIP	Y
22	SPI	WTI HV Y PH TRIP	Y
23	SPI	WTI HV B PH TRIP	Y
24	SPI	WTI HV SPARE ICT TRIP	Y
25	SPI	WTI MV R PH TRIP	Y
26	SPI	WTI MV Y PH TRIP	Y
27	SPI	WTI MV B PH TRIP	Y
28	SPI	WTI MV SPARE ICT TRIP	Y
29	SPI	WTI IV R PH TRIP	Y

REQUIRED SIGNALS FOR ICT REF RELAYS			
SL. NO.	**TYPE**	**EVENT/ALARM NAME**	**WHETHER ALARM TO BE GENERATED**
30	SPI	WTI IV Y PH TRIP	Y
31	SPI	WTI IV B PH TRIP	Y
32	SPI	WTI IV SPARE ICT TRIP	Y
33	SPI	BUCCHOLZ R PH ALARM	Y
34	SPI	BUCCHOLZ Y PH ALARM	Y
35	SPI	BUCCHOLZ B PH ALARM	Y
36	SPI	BUCCHOLZ SPARE ICT ALARM	Y
37	SPI	OSR 2 R PH TRIP	Y
38	SPI	OSR 2 Y PH TRIP	Y
39	SPI	OSR 2 B PH TRIP	Y
40	SPI	OSR 2 SPARE ICT TRIP	Y
41	SPI	PRD 2 R PH TRIP	Y
42	SPI	PRD 2 Y PH TRIP	Y
43	SPI	PRD 2 B PH TRIP	Y
44	SPI	PRD 2 SPARE ICT TRIP	Y
45	SPI	GOOSE RECEIPT FAIL/TROUBLE	Y
46		**ANY ADDITIONAL SIGNAL AS PER SCHEME**	

REQUIRED SIGNALS FOR DIRECTIONAL OVERCURRENT AND EARTH FAULT RELAYS			
SL. NO.	**TYPE**	**EVENT/ALARM NAME**	**WHETHER ALARM TO BE GENERATED**
1	SPI	DEF START	
2	SPI	DEF GEN TRIP	Y
3	SPI	DIRECTIONAL OVERCURRENT START	Y
4	SPI	DIRECTIONAL OVERCURRENT TRIP	Y
5	SPI	GENERAL TRIP	Y

6	System Diagnosis (SON)	TIME SYNCHRONIZATION ERROR	Y
7	System Diagnosis (SON)	M1 IED UNHEALTHY	Y
8	SPI	GOOSE RECEIPT FAIL/TROUBLE	Y
9		**ANY ADDITIONAL SIGNAL AS PER SCHEME**	

REQUIRED SIGNALS FOR REACTOR DIFFERENTIAL RELAYS

SL.NO.	TYPE	EVENT/ALARM NAME	WHETHER ALARM TO BE GENERATED
1	SPI	DIFFERENTIAL PROTECTION TRIP	Y
2	SPI	DIFFERENTIAL CURRENT ALARM	Y
3	SPI	TEE DIFFERENTIAL PROTECTION TRIP	Y
4	System Diagnosis (SON)	TIME SYNCHRONIZATION ERROR	Y
5	System Diagnosis (SON)	DIFFRENTIAL IED UNHEALTHY	Y
6	SPI	DIFFERENTIAL RELAY GENERAL TRIP	Y
7	SPI	OTI ALARM	Y
8	SPI	WTI ALARM	Y
9	SPI	BUCCHOLZ TRIP	Y
10	SPI	OSR TRIP	Y
11	SPI	PRD TRIP	Y
12	SPI	FIRE PROTECTION OPERATED	Y
13	SPI	LOW OIL LEVEL	Y
14	SPI	OTI R PH ALARM	Y
15	SPI	OTI Y PH ALARM	Y

16	SPI	OTI B PH ALARM	Y
17	SPI	OTI SPARE PH ALARM	Y
18	SPI	WTI R PH ALARM	Y
19	SPI	WTI Y PH ALARM	Y
20	SPI	WTI B PH ALARM	Y
21	SPI	WTI SPARE ICT ALARM	Y
22	SPI	BUCCHOLZ R PH TRIP	Y
23	SPI	BUCCHOLZ Y PH TRIP	Y
24	SPI	BUCCHOLZ B PH TRIP	Y
25	SPI	BUCCHOLZ SPARE PH TRIP	Y
26	SPI	OSR R PH TRIP	Y
27	SPI	OSR Y PH TRIP	Y
28	SPI	OSR B PH TRIP	Y
29	SPI	OSR SPARE ICT TRIP	Y
30	SPI	PRD R PH TRIP	Y
31	SPI	PRD Y PH TRIP	Y
32	SPI	PRD B PH TRIP	Y
33	SPI	LOW OIL LEVEL R PH	Y
34	SPI	LOW OIL LEVEL Y PH	Y
35	SPI	LOW OIL LEVEL B PH	Y
36	SPI	LOW OIL LEVEL SPARE ICT	Y
37	SPI	FIRE PROTECTION R PH OPERATED	Y
38	SPI	FIRE PROTECTION Y PH OPERATED	Y
39	SPI	FIRE PROTECTION B PH OPERATED	Y
40	SPI	FIRE PROTECTION SPARE ICT OPERATED	Y
41	SPI	MAIN CB R PH OPEN	Y
42	SPI	MAIN CB Y PH OPEN	Y
43	SPI	MAIN CB B PH OPEN	Y

44	SPI	TIE CB R PH OPEN	Y
45	SPI	TIE CB Y PH OPEN	Y
46	SPI	TIE CB B PH OPEN	Y
47	SPI	TRIP RELAY 86 A HEALTHY (SUPERVISION)	Y
48	SPI	TRIP RELAY 86 B HEALTHY (SUPERVISION)	Y
49	SPI	GR A RELAY OPERATED	Y
50	SPI	GR B RELAY OPERATED	Y
51	SPI	REF RELAY FAIL	Y
52	SPI	REACTOR CB R PH OPEN	APPLICABLE FOR SWITCHABLE REACTOR APPLICATION
53	SPI	REACTOR CB Y PH OPEN	
54	SPI	REACTOR CB B PH OPEN	
55	SPI	REACTOR CB SPARE PH OPEN	
56	SPI	GR A RELAY OPERATED	Y
57	SPI	GR B RELAY OPERATED	Y
58	SPI	GOOSE RECEIPT FAIL/TROUBLE	Y
59	SPI	**ANY ADDITIONAL SIGNAL AS PER SCHEME**	

REQUIRED SIGNALS FOR REACTOR REF RELAYS			
SL. NO.	**TYPE**	**EVENT/ALARM NAME**	**WHETHER ALARM TO BE GENERATED**
1	System Diagnosis (SON)	TIME SYNCHRONIZATION ERROR	Y

2	System Diagnosis (SON)	DIFFRENTIAL IED UNHEALTHY	Y
3	SPI	REF RELAY ALARM	Y
4	SPI	REF TRIP	Y
5	SPI	GENERAL TRIP	Y
6	SPI	REF TRIP	Y
7	SPI	OTI TRIP	Y
8	SPI	WTI TRIP	Y
9	SPI	BUCCHOLZ ALARM	Y
10	SPI	OTI R PH TRIP	Y
11	SPI	OTI Y PH TRIP	Y
12	SPI	OTI B PH TRIP	Y
13	SPI	OTI SPARE ICT TRIP	Y
14	SPI	WTI R PH TRIP	Y
15	SPI	WTI Y PH TRIP	Y
16	SPI	WTI B PH TRIP	Y
17	SPI	WTI SPARE PH TRIP	Y
18	SPI	BUCCHOLZ R PH ALARM	Y
19	SPI	BUCCHOLZ Y PH ALARM	Y
20	SPI	BUCCHOLZ B PH ALARM	Y
21	SPI	BUCCHOLZ SPARE PH ALARM	Y
22	SPI	GOOSE RECEIPT FAIL/TROUBLE	Y
23		**ANY ADDITIONAL SIGNAL AS PER SCHEME**	

REQUIRED SIGNALS FOR REACTOR BACKUP IMPEDANCE PROTECTION RELAY			
SL. NO.	**TYPE**	**EVENT/ALARM NAME**	**WHETHER ALARM TO BE GENERATED**
1	SPI	START Z1	
2	SPI	Z1 TRIP	Y

3	SPI	GENERAL TRIP	Y
4	DINT	FAULT LOCATOR DISTANCE	
5	SPI	CVT FUSE FAIL	Y
6	System Diagnosis (SON)	TIME SYNCHRONIZATION ERROR	Y
7	System Diagnosis (SON)	M1 IED UNHEALTHY	Y
22	SPI	GOOSE RECEIPT FAIL/TROUBLE	Y
8		**ANY ADDITIONAL SIGNAL AS PER SCHEME**	

REQUIRED SIGNALS FOR BUS BAR PROTECTION RELAYS			
SL.NO.	**TYPE**	**EVENT/ALARM NAME**	**WHETHER ALARM TO BE GENERATED**
1	SPI	BUS ZONE 1 TRIP	Y
2	SPI	BUS ZONE 2 TRIP	Y
3	SPI	BUS BAR BLOCKED EXTERNAL	Y
4	SPI	BUS BAR BLOCKED DUE TO COMMUNICATIONN ERROR	Y
5	SPI	BUS BAR BLOCKED DUE TO INTERMEDIATE STATUS	Y
6		CT CIRCUIT ERROR	Y

REQUIRED SIGNALS FOR BREAKER FAILURE PROTECTION RELAY PROTECTION RELAY			
SL. NO.	**TYPE**	**EVENT/ALARM NAME**	**WHETHER ALARM TO BE GENERATED**
1	SPI	BREAKER FAILURE PROTECTION START	Y
2	SPI	BREAKER FAILURE TRIP	Y
3	SPI	BREAKER FAILURE RETRIP	Y

4	System Diagnosis (SON)	TIME SYNCHRONIZATION ERROR	Y
5	System Diagnosis (SON)	M1 IED UNHEALTHY	Y
6	SPI	GOOSE RECEIPT FAIL/TROUBLE	Y
7			
8		**ANY ADDITIONAL SIGNAL AS PER SCHEME**	

REQUIRED SIGNALS FOR BAY CONTROL UNIT				
SL.NO.	**TYPE**	**EVENT/ALARM NAME**	**WHETHER ALARM TO BE GENERATED**	**ADDITIONAL REMARKS**
1	INT	BCU IN LOCAL/ REMOTE		
2	SPI	CLOSE COMMAND FROM BCU FOR AUTORECLOSE		
3	SPI	BLOCK AUTORECLOSE FUNCTION	Y	
4	**INT**	**STATUS 1 AUTORECLOSE FUNCTION READY**		
		STATUS 2 AUTORECLOSE IN PROGRESS	**Y**	
		STATUS 3 AUTORECLOSE SUCCESSFUL	**Y**	
		STATUS 10 AUTORECLOSE UNSUCCESSFUL	**Y**	Available in Edition 2 IEDs, not in Edition 1 IEDs
5	CMD	BAY_CB_COMMAND		
6	SPI	BAY_CB_OPEN PERMITTED OR ENABLED		

REQUIRED SIGNALS FOR BAY CONTROL UNIT				
SL.NO.	**TYPE**	**EVENT/ALARM NAME**	**WHETHER ALARM TO BE GENERATED**	**ADDITIONAL REMARKS**
7	SPI	BAY_CB_CLOSE PERMITTED OR ENABLED		
8	DPI	BAY_CB R PH POSITION		
9	DPI	BAY_CB Y PH POSITION		
10	DPI	BAY_CB B PH POSITION		
11	DPI	BAY_89A_ISOLATOR POSITION		
12	CMD	BAY_89A_ISO COMMAND		
13	SPI	BAY_89A_ISO OPEN PERMITTED OR ENABLED		
14	SPI	BAY 89A_CLOSE PERMITTED OR ENABLED		
15	DPI	BAY_89AE_ISOLATOR POSITION		IF BUS EARTH SWITCH IS IN THE BAY FOR WHICH THE ASSIGNMENT IS BEING DONE, CSWI3 SHALL BE USED FOR 89 AE 1, i.e. BUS EARTH SWITCH. FOR BAY SIDE EARTH SWITCH (89AE2) SEPARATE LOGICAL NODE CSWI 10 IS PROVIDED BELOW
16	CMD	BAY_89AE_ISO COMMAND		
17	SPI	BAY_89AE_ISO OPEN PERMITTED OR ENABLED		
18	SPI	BAY_89AE_CLOSE PERMITTED OR ENABLED		
19	DPI	BAY_89 B_ISOLATOR POSITION		
20	CMD	BAY_89 B_ISO COMMAND		
21	SPI	BAY_89 B_ISO OPEN PERMITTED OR ENABLED		
22	SPI	BAY_89 B_CLOSE PERMITTED OR ENABLED		
23	DPI	BAY_89 BE_ISOLATOR		

REQUIRED SIGNALS FOR BAY CONTROL UNIT				
SL.NO .	**TYPE**	**EVENT/ALARM NAME**	**WHETHER ALARM TO BE GENERATED**	**ADDITIONAL REMARKS**
		POSITION		
24	CMD	BAY_89 BE_ISO COMMAND		
25	SPI	BAY_89 BE_ISO OPEN PERMITTED OR ENABLED		
26	SPI	BAY_89 BE_CLOSE PERMITTED OR ENABLED		
27	DPI	BAY_89 C/L/T_ISOLATOR POSITION		FOR 3 PHASE TRANSFORMER S CSWI7 MAY BE USED FOR 89 T BUT FOR SINGLE PHASE TRANSFORMER S SAME HAS BEEN SEPARATELY MENTIONED
28	CMD	BAY_89 C/L/T_ISO COMMAND		
29	SPI	BAY_89 C/L/T_ISO OPEN PERMITTED OR ENABLED		
30	SPI	BAY_89 C/L/T_CLOSE PERMITTED OR ENABLED		
31	DPI	BAY_89 CE/LE/TE_ISOLATOR POSITION		FOR 3 PHASE TRANSFORMER S CSWI7 MAY BE USED FOR 89 TE BUT FOR SINGLE PHASE TRANSFORMER S SAME HAS BEEN SEPARATELY MENTIONED
32	CMD	BAY_89 CE/LE/TE_ISO COMMAND		
33	SPI	BAY_89 CE/LE/TE_ISO OPEN PERMITTED OR ENABLED		
34	SPI	BAY_89 CE/LE/TE_CLOSE PERMITTED OR ENABLED		
35	DPI	BAY_89 R_ISOLATOR POSITION		
36	CMD	BAY_89 R_ISO COMMAND		
37	SPI	BAY_89 R_ISO OPEN PERMITTED OR ENABLED		
38	SPI	BAY_89 R_CLOSE PERMITTED OR ENABLED		
39	DPI	BAY_89 RE_ISOLATOR POSITION		

REQUIRED SIGNALS FOR BAY CONTROL UNIT				
SL.NO.	**TYPE**	**EVENT/ALARM NAME**	**WHETHER ALARM TO BE GENERATED**	**ADDITIONAL REMARKS**
40	CMD	BAY_89 RE_ISO COMMAND		
41	SPI	BAY_89 RE_ISO OPEN PERMITTED OR ENABLED		
42	SPI	BAY_89 RE_CLOSE PERMITTED OR ENABLED		
43	DPI	BAY_89AE 2_ISOLATOR POSITION		USED FOR SECOND EARTH SWITCH OF ISOLATOR, WHEN BUS EARTH SWITCH IS PROVIDED
44	CMD	BAY_89AE 2_ISO COMMAND		
45	SPI	BAY_89AE 2_ISO OPEN PERMITTED OR ENABLED		
46	SPI	BAY_89AE 2_CLOSE PERMITTED OR ENABLED		
THE LOGICAL NODES FOR ISOLATOR & EARTHSWITCHES FOR 3 PH ICTs & REACTORS , e.g 89 RR,RR1,RR2 & RE and for 89TR,TR1,TR2,TRE MAY BE ASSIGNED AS PER AVAILABILITY				
47	System Diagnosis (SON)	TIME SYNCHRONIZATION ERROR	Y	
48	System Diagnosis (SON)	BCU UNHEALTHY	Y	
49	SPI	CONDITIONS OK FOR SYNCHRONIZATION		
50	SPI	SPRING DISCHARGED	Y	ANNUNCIATION FOR CIRCUIT BREAKER
51	SPI	AC MOTOR SUPPLY FAIL	Y	
52	SPI	SF6 GAS LOW	Y	
53	SPI	OPERATION LOCKED OUT	Y	
54	SPI	CB READY FOR AUTORECLOSURE	Y	
55	SPI	DC SUPPLY FAIL	Y	

REQUIRED SIGNALS FOR BAY CONTROL UNIT				
SL.NO.	**TYPE**	**EVENT/ALARM NAME**	**WHETHER ALARM TO BE GENERATED**	**ADDITIONAL REMARKS**
56	SPI	TC-1 FAIL	Y	
57	SPI	TC-2 FAIL	Y	
58	SPI	POLE DISCREPANCY RELAY OPTD	Y	
59	SPI	COMPRESSOR SUPPLY FAIL	Y	
60	SPI	AIR PRESSURE LOW	Y	
61	SPI	COMPRESSOR RUN TIME SUPERVISION	Y	
62	SPI	CSD FAIL	Y	
63	SPI	GAS COMPARTMENT n Alarm Stage n	Y	ANNUNCIATION FOR GIS BAYS
64	SPI	LCC PANEL AC SUPPLY FAIL	Y	
65	SPI	LCC PANEL DC SUPPLY FAIL	Y	
66	SPI	SELECTOR SWITCH POSITION LOCAL/REMOTE	Y	
67	SPI	BUS VT MCB TRIP	Y	FOR BCUs HAVING BUS VT INPUT
6	SPI	GOOSE RECEIPT FAIL/TROUBLE	Y	
68	SPI	ADDL SIGNALS FOR CB TROUBLE ETC AS PER SCHEME		

6. List of Signal for Station Auxiliaries Panel (SAS)
110V DC

1. Voltage of 110V DCDB-1
2. Voltage of 110V DCDB-2
3. Current from 110V Battery Set -1
4. Current from 110V Battery Set -2
5. Current from 110V Battery Charger -1
6. Current from110V Battery charger 2
7. Battery 1 Output Voltage
8. Battery 2 Output Voltage
9. Charger Trouble 1
10. Charger Trouble 2
11. Charger 1 on Boost
12. Charger 1 on Float
13. Charger 1 Failure (Float)

14. Charger 1 Failure (FCBC)
15. Charger 2 on Boost
16. Charger 2 on Float
17. Charger 2 Failure (Float)
18. Charger 2 Failure (FCBC)
19. Charger 1 Float Current
20. Charger 1 Boost Current
21. Charger 2 Float Current
22. Charger 2 Boost Current
23. Input MCCB Incomer-1 ON (DCDB)
24. Input MCCB Incomer-2 ON (DCDB)
25. DCDB Bus coupler MCCB OFF
26. DC Earth Fault Relay Operated Sec-I
27. DC Earth Fault Relay Operated Sec-II
28. 415 V AC Supply MCCB-1 Trip
29. 415 V AC Supply MCCB-2 Trip
30. Over Temperature Indication
31. DC Overvoltage and Undervoltage relay operated
32. AC Supply Trouble (Charger)

Separate Signal for both Charger 1, Charger 2, DCDB 1 and DCDB 2

48 V DC

1. Voltage of 48 V DCDB 1
2. Voltage of 48 V DCDB 2
3. Current from 48 V Battery set 1
4. Current from Battery Set 2
5. Current from 48 V Charger 1
6. Current from 48 V Charger 2
7. Battery 1 Output Voltage
8. Battery 2 Output Volatge
9. Charger Trouble 1
10. Charger Trouble 2
11. Charger 1 on Boost
12. Charger 1 on Float
13. Charger 1 Failure (Float)
14. Charger 1 Failure (FCBC)
15. Charger 2 on Boost
16. Charger 2 on Float
17. Charger 2 Failure (Float)
18. Charger 2 Failure (FCBC)
19. Charger 1 Float Current
20. Charger 1 Boost Current
21. Charger 2 Float Current
22. Charger 2 Boost Current
23. Input MCCB Incomer-1 ON (DCDB)
24. Input MCCB Incomer-2 ON (DCDB)
25. DCDB Bus coupler MCCB OFF
26. DC Earth Fault Relay Operated Sec-I
27. DC Earth Fault Relay Operated Sec-II
28. 415 V AC Supply MCCB-1 Trip
29. 415 V AC Supply MCCB-2 Trip
30. Over Temperature Indication
31. DC Overvoltage and Undervoltage relay operated
32. AC Supply Trouble (Charger)

DG Set

1. DG Set Breaker ON

2. DG Set Breaker OFF
3. Low Lube Oil Pressure
4. High Water Temperature
5. Engine Over Speed
6. Low Fuel in Service Tank
7. Over load Trip
8. Voltage RY, YB and BR
9. Current from DG set R, Y and B

Fire Fighting

1. Zone 1 Fire
2. Zone 2 Fire
3. Zone 3 Fire
4. Zone 4 Fire
5. Zone 5 Fire

Other Signal

1. PLCC Exchange Fail
2. Time Synch. Signal Fail
3. GPS Signal Fail
4. Current from Station transformer
5. Voltage from Station Transformer
6. Isolator Status of Station Transformer
7. Ambient Temperature .

CHAPTER 16: GIS EQUIPMENTS

16.1 GENERAL

The GIS manufacturer shall design, manufacture, test, deliver at site, **commission** and guarantee the GIS components and services as defined in this Technical Specification.. The complete GIS based on the Single Line Diagram shall be provided for connection to Power Transformers/Reactors/Lines feeders with associated circuit breaker, disconnect switch and grounding switch (maintenance and high speed), instrument transformers, and surge arrestor (if applicable) etc.

16.2 GENERAL CHARACTERISTICS

16.2.1 The SF6 gas insulated metal enclosed switchgear shall be totally safe against inadvertent touch of any of it's constituent parts. It should be designed for indoor application with meteorological conditions as specified.

16.2.2 All parts of the bus bar, switchgear and the bus ducts (for both indoor and outdoor applications) shall be as mentioned below:

400 kV GIS	Single phase enclosed
220kV GIS	Single Phase/Three Phase enclosed
132 KV GIS	Three Phase enclosed

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16.2.3 The design should be such that all parts subjected to wear and tear are easily accessible for maintenance purposes. The equipment offered shall be protected against all types of voltage surges and any equipment necessary to satisfy this requirement shall deemed to be included.

16.3 REFERENCE STANDARDS

The GIS offered shall confirm to IEC 62271-203 and other relevant IEC standard except to the extent explicitly modified in the specification and shall be in accordance with requirement specified in general design criteria The metal-enclosed gas-insulated switchgear, including the operating devices, accessories and auxiliary equipment forming integral part thereof, shall be designed, manufactured, assembled and tested in accordance with the following International Electro-technical Commission (IEC) Publications including their parts and supplements as amended or revised as on date of bid opening:

IEC 62271-1	: High-voltage switchgear and control gear Part 1: Common specifications
IEC 62271-203	: High-voltage switchgear and control gear Part 203: Gas- insulated metal-enclosed switchgear for rated voltages above 52 kV 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 Disconnectors, earthin switches.
IEC 62271-102	: High-voltage switchgear and control gear Part 102: Alternating- current dis-connectors and earthing switches Instrument transformers:
IEC 62271-303	: High-voltage switchgear and control gear – Use and handling of sulphur hexafluoride (SF_6)
IEC 61000	: Electromagnetic compatibility (EMC)
IEC 60060	: High voltage test techniques
IEC 60071	: Insulation co-ordination
IEC 60255	: Electrical relays
IEC 60265	: High voltage switches
IEC 60270	: High-voltage test techniques - Partial discharge measurements
IEC 60376	: Specification and acceptance of new sulphur hexafluoride
IEC 60480	: Guide to checking of sulphur hexafluoride (SF_6)
IEC 60529	: Degrees of protection provided by enclosures (IP Code)
IEC 60815	: Guide for the selection of insulators in respect of polluted conditions
IEC 61869/60044/60185/60186/60044-6:	: Instrument transformers
IEC 60364 / 60479 / 60621 / IEEE std. 80/CIGRE 44	: Standards for station grounding
CENELEC/SVDB**/ASME**:	Boiler & Pressure vessel code
IEC 693	: Seismic Design
IEC 62271-207	Seismic qualification for gas-insulated switchgear assemblies for rated voltages above 52 kV
IEC 60137	Bushings for alternating voltages above 1000 V
IEC 62271-209	Cable connections for gas-insulated switchgear
IEC 60099 -1/4	Non-linear resistor type arresters for AC systems
IEC 60439	Factory-built assemblies of low-voltage switchgear and control Gear.
IEEE 80 2013	IEEE Guide for Safety in AC Substation grounding.
CIGRE-44	Earthing of GIS- an application guide.
IEC 62271-211	Direct connection between Power Transformers and gas insulated metal enclosed switchgear for rated voltage 72.5 kV and above.

Cable Connections:

IEC 62271-209: High-voltage switchgear and control gear Part 209: Cable connections for gas-insulated metal-enclosed switchgear for rated voltages above 52 kV – Fluid-filled and dry- type cable-terminations

Outdoor Bushings:

IEC 60137: Insulated Bushings For Alternating Voltages Above 1000 V Transformer Direct Connection:

Iec 61639: Direct Connection Between Power Transformers And Gas-Insulated Metal-Enclosed Switchgear For Rated Voltages Of 72.5 Kv And Above.

Surge Arresters:

Iec 60099-4: Surge Arresters Part 4: Metal-Oxide Surge Arreste rs Without Gaps For A.C. Systems SF6-Gas:

IEC 60480: Guidelines for the checking and treatment of sulphur hexafluoride (SF6) taken from electrical equipment and specification for its re-use

IEC/TR 62271-303: High-voltage switchgear and control gear Part 303: Use and handling Of sulphur hexafluoride (SF6) Local Control Cubicles:

IEC 61439 -1: Low-voltage switchgear and control gear assemblies Part 1: General rules EMC. IEC 62271-1: High-voltage switchgear and control gear Part 1: Common specifications

IEC 60267 Out of phase switching of Circuit Breaker

IEC 60129 Inductive current breaking

IEC 61128: Bus transfer capability of disconnecting switch

IEC 60859: Cable termination design

The components and devices which are not covered by the above standards shall conform to, and comply with, the applicable standards, rules, codes and regulations of the internationally recognized standardizing bodies and professional societies as may be approved by the Employer and the manufacturer shall list all such applicable standards, codes etc. The manufacturer shall supply those standards (soft copy) as and when required by AEGCL without any extra cost borne to AEGCL.

In case the requirements laid down herein differ from those given in above standard in any aspect the switchgear shall comply with the requirements indicated herein in regard thereto.

Modular Design

Housings and expansion joints together form the pressure-resistant enclosure of the switchgear. The housings are made of cast aluminium alloy **or high-grade steel of adequate thickness to withstand internal arc test (burn through test) for minimum 300ms**,the expansion joints of high-grade steel and the covers of steel or aluminium.

The manufacturing and testing of the housings are state-of-the-art technology. Each, housing is subject to a pressure and gas tightness test and complies with the requirements of the relevant CENELEC standard.

Surface Treatment Steel (covers):

Indoor structure: Hot galvanised or painted Outdoor structure: Hot galvanised and painted High-Grade Steel (expansion joints):

Indoor Pre-treatment: none Paint work: none

Outdoor Pre-treatment: degrease

Paint work: same as housings of cast aluminium

Cast-Aluminium:

Pre-treatment (indoor and outdoor): Sand-blast or degrease alkaline

Internal surfaces (cast-aluminium): As per manufacturers type tested design Internal surfaces (aluminium wrought alloy): without surface treatment

External surfaces material description: high-resistant 2-component **epoxy paint:**

As per manufacturers type tested design Gas, Gas compartments, monitoring of gas compartments:

SF6 serves as insulation for the enclosure of several separately-sealed gas compartments

Static filters in all gas compartments – with single-phase encapsulation for each phase for single phase encapsulation design - absorb moisture and decomposition products; the filter material is placed in filter bags which are supplied in airtight cans all gas compartments are equipped with rupture diaphragms and, if necessary, with gas diverter nozzles; these nozzles are arranged in a way that, if the rupture diaphragm bursts, the gas flow is guided away in a direction not unnecessary hazardous to either personnel or equipment the modules of circuit-breakers, voltage transformers, cable connection module and surge arresters form separate gas compartments. The disconnector gas compartment can contain other device like earthing switch the switch operating shafts are supported and provided with lip seals against pressure and vacuum loss in such a way that during the evacuation process before commissioning no air can penetrate and no SF6 can escape during operation; the leakage rate is less than 0.5 % SF6 per year and gas compartment.

The gas pressure is monitored by density monitors with indication; density monitors are installed directly at the gas compartment they monitor.

16.4 GENERAL DESIGN AND SAFETY REQUIREMENT

16.4.1 The GIS shall be designed, manufactured and tested in accordance with the best international engineering practices under strict quality control to meet the requirement stipulated in the technical specification. Adequate safety margin with respect to thermal, mechanical, dielectric stress and insulation coordination etc. shall be maintained during design, selection of raw material, manufacturing process etc. so that the GIS provides longlife with least maintenance.

The workmanship shall be of the highest quality and shall conform to the latest modern practices for the manufacture of high technology machinery and electrical switchgear.

16.4.2 The GIS assembly shall consist of separate modular compartments e.g. Circuit Breaker compartment, Bus bar compartment filled with SF6 Gas and separated by gas tight partitions so as to minimize risk to human life, allow ease of maintenance and limit the effects of gas leaks failures & internal arcs etc. These compartments shall be such that maintenance on one feeder may be performed without de-energising the adjacent feeders. These compartments shall be designed to minimize the risk of damage to adjacent sections and protection of personnel in the event of a failure occurring within the compartments. Rupture diaphragms with suitable deflectors shall be provided to prevent uncontrolled bursting pressures developing within the enclosures under worst operating conditions, thus providing controlled pressure relief in the affected compartment.

16.4.3 The switchgear, which shall be of modular design, shall have complete phase isolation. The conductors and the live parts shall be mounted on high graded epoxy resin insulators. These insulators shall be designed to have high structural strength and electrical dielectric properties and shall be free of any voids and free of partial discharge at a voltage which is at least 5% greater than the rated voltage. These shall be designed to have high structural and dielectric strength properties and shall be shaped so as to provide uniform field distribution and to minimize the effects of particle deposition either from migration of foreign particles within the enclosures or from the by-products of SF6 breakdown under arcing conditions.

16.4.4 All circuit breakers, disconnect switches and other component of GIS having identical rating shall have identical and interchangeable parts and operating mechanism as far as possible.

16.4.5 Gas barrier insulators shall be provided so as to divide the GIS into separate compartments. These shall be suitably located in order to minimize disturbance in case of leakage or dismantling. They shall be designed to withstand any internal fault thereby keeping an internal arc inside the faulty compartment. Further, it is prohibited to work adjacent to a gas compartment while it is fully pressurized on the other side. For such cases, the gas pressure in the adjacent compartments needs to be reduced.

16.4.6 Disconnector and Earth switch module shall not be combined with bus bar module in same gas zone. Cable termination module shall be in separate gas zone.

16.4.7 Expansion joints provided to be locked in place after alignment is complete considering calculated maximum thermal expansion for all plug-in contacts. Pressure relief device shall be provided in each gas partition module along with moisture adsorber located in a suitable place. 100 micro-meter or smaller sintered stainless-steel particle filtered disc shall be provided in gas filling port.

16.4.8 Conductive particle traps shall be placed at support insulators (free from all voids), non-tracking type with sufficient mechanical and electrical strength. Single or double mitered elbows shall be used with bus duct depending on mechanical stress.

16.4.9 Cable termination module with removable link shall be designed as per IEEE 1300 or IEC 60859. SF6 to air bushing module shall be provided with bursting disc (rupture disc) of adequate design. GIS to transformer connection module shall be provided with self-compensating bellow located just above the transformer end termination point.

16.4.10 The switchgear must be sectionalized, with gas tight barriers between sections or compartments. The sections shall be designed to minimize operational shut down when the gas pressure is reduced due to Leakage or for maintenance purposes. Also, to minimize the quantity of gas that has to be evacuated and recharged before and after maintaining any item of equipment.

16.4.11 .

16.4.12 Each section shall be provided with necessary valves to allow evacuation and refill of gas without evacuation of any other section.

16.4.13 The gas system proposed shall be submitted with the proposal. External fixtures shall be of non-corrosive material and be capped wherever required.

16.4.14 For the purpose of gas monitoring and maintenance, the GIS shall be provided with gas density monitoring device along with temperature compensated gas density switch having two stage contacts in each gas compartment. Pressure relief devices shall be used wherever required.

16.4.15 Support insulators shall be used to maintain the conductors and enclosure in proper relation.

16.4.16 Barrier insulators which are employed to isolate gas compartments as well as support insulators shall be manufactured from high quality epoxy resin, free of all voids and be designed to reduce the electrical stress on the insulators to a minimum. The support insulator shall have holes on both sides for proper flow of gas.

16.4.17 The mechanical strength must be sufficient to ensure the conductor’s space requirements and clearances when short circuit faults occur. In addition, the gas barrier insulators sealing to the conductors and the enclosure wall shall be designed to withstand the maximum gas pressure differential under normal operating condition and maximum pressure differential with one of the adjacent enclosures at three times operating gas pressure and the other at atmospheric pressure for five minutes. Its safety factor shall be as per IEC. **The GIS module shall be suitable to operate continuously when the inside SF6 pressure is equivalent to outside SF6 pressure.**

Tests shall be carried out during the manufacturing of the switchgear to ensure that all insulators are free of partial discharge at a voltage which is at least 10% higher than the rated voltage.

Gas System

The GIS shall be furnished with sufficient sulphur hexa-fluoride (SF6) gas to pressurize the complete system in a sequential approach, one zone or compartment at a time to the rated nominal density.

During commissioning, the dew point of SF6 gas shall be measured and documented. Maximum water content of SF6 -gas in GIS, within guarantee period:

CB ≤ 150 PPM (volume) Others ≤ 500 PPM (volume)

The Gas loss of the switchgear shall be in no case higher than 0.5% per year.

No copper tubing between the phase for equalizing the gas pressure will be accepted.

Gas Seals

All gas seals shall be designed to ensure that leakage rates are kept to an absolute minimum under all normal pressure, temperature, electrical load and fault conditions. All gas seals located in the flanges of the equipment enclosures shall be of the O-ring type. The material and method of sealing used shall be stated in the tender.

Gas filters / treatment

Each gas compartment shall be fitted with gas filters, driers or desiccants for the absorption of moisture and the gaseous products of switching. The filter shall be effective for the duration of time between major overhaul. It shall be possible to replace the active material of the filter without extensive dismantling. The absorbent shall be located in an easily accessible location. The tenderer shall indicate the detail and type of filters used in the various gas sections.

Gas Monitoring Devices

Temperature-compensated gas density monitoring devices shall be provided for each gas compartment. The devices shall provide continuous and online monitoring (Display at SAS) of the density of the gas. The monitoring device shall have two alarm settings. These shall be set so that:

First stage: Advanced warning can be given that the gas density is approaching an unacceptably low level Second stage: The relevant GCB can be locked for tripping/ closing.

SF6 Gas Treatment

Under normal operating conditions it shall not be necessary to treat the insulating SF6 gas between major overhauls. Normally closed valve shall be provided to facilitate filling and recharging. In all gas compartments permanent efficient filters and drying agent shall be at least effective for the duration of time between major overhauls. The filters shall be capable of absorbing the by-products of SF6 gas during interruption.

16.4.18 The switchgear shall be of the free standing, self-supporting with easy accessibility to all the parts during installation & maintenance with all high-voltage equipment installed inside gas-insulated metallic and earthed enclosures. GIS should be suitably sub-divided into individual arc and gas-proof compartments preferably for:

1) Bus bars
2) Intermediate compartment
3) Circuit breakers
4) Feeder Disconnect Switch
5) Voltage Transformers
6) Gas Insulated bus duct section between GIS and XLPE cable/Overhead Conductor.
7) Gas Insulated bus section between GIS & Oil filled Transformer/ Reactor (ifapplicable)

16.4.19 **SERVICE CONTINUITY REQUIREMENT:**

The GIS equipment with the given bus switching arrangement is divided into different gas compartments. During the work such as a fault repair or major maintenance, requiring the dismantling of a gas compartment for which more than one compartments may need to be de-gassed.

Working conditions, method statements and procedures are to be furnished by the GIS manufacturer in order to ensure equipment and operating personnel's safety and to achieve following Service continuity conditions to the extent possible:

16.4.11.1 For One & half breaker bus switching scheme during a fault in CB compartment, No bus bar and feeder is permitted out of service during maintenance and repair/replacement.

16.4.11.2 For Double Main bus switching scheme during a fault in CB compartment, No bus bar permitted out of service during maintenance and repair/replacement.

16.4.11.3 During a fault in GIS compartment other than CB compartment, maximum one bus bar and/or one feeder permitted out of service during maintenance and repair/replacement.

Repair

In case of any internal fault in the bus bar or bus bar dis - connector, circuit breaker, grounding switches etc., repair works must be possible with at least one busbar in service. In case of any type of fault in any section of the line bay, transformer bay or bus coupler bay modules, repair works must be possible.

Any failure shall be immediately signaled by the systems inherent self-supervision with clear description of the nature and the location of this failure. Generally, any failure shall have impact only on the direct related devices and the rest of the substation shall remain in normal operation.

Removal of Components

The GIS shall be designed so that any component of the GIS can be easily removed. As minimum flexibility in the layout arrangement, it shall be possible to remove the circuit breaker with both bus bar remaining in service and it shall be possible to remove the dis connector of the bus bars, with one bus bar remaining in service.

16.4.20 The material and thickness of the enclosures shall be such as to withstand an internal flash over without burns through for a period of 300 ms at rated short time withstand current. The material shall be such that it has no effect of environment as well as from the by-products of SF6 breakdown under arcing condition. This shall be validated with Type Test.

16.4.21 Each section shall have plug- in or easily removable connection pieces to allow for easy replacement of any component with the minimum of disturbance to the remainder of the

16.4.22 equipment. Inspection windows (View Ports) shall be provided for Disconnect Switch and both type of earth switches i.e. Maintenance and fast operating. **Stroboscopic port shall also be provided.**

16.4.23 The material used for manufacturing the switchgear equipment shall be of the type, composition and have physical properties best suited to their particular purposes and in accordance with the latest engineering practices. All the conductors shall be fabricated of aluminum/ copper tubes of cross sectional area suitable to meet the normal and short circuit current rating requirements. The finish of the conductors shall be smooth so as to prevent any electrical discharge. The conductor ends shall be silver plated and fitted into finger contacts or tulip contacts. The contacts shall be of sliding type to allow the conductors to expand or contract axially due to temperature variation without imposing any mechanical stress on supporting insulators. Field welding of the conductor is not acceptable.

16.4.24 Each pressure filled enclosure shall be designed and fabricated to comply with the requirements of the applicable pressure vessel codes and based on the design temperature and design pressures as defined in IEC-62271-203.

16.4.25 The maximum SF6 gas leakage shall not exceed 0.5% (half percent) per year for the whole equipment and for any individual gas compartment separately. The SF6 gas leakage should not exceed 0.5% per year and the leakage rate shall be guaranteed for at least 10 years. In case the leakage under the specified conditions is found to be greater than 0.5% after one year of commissioning, the manufacturer will have to supply free of cost, the total gas requirement for subsequent ten (10) years, based on actual leakage observed during the first year of operation after commissioning.

16.4.26 Each gas-filled compartment shall be equipped with static filters, density switches, filling valve, rupture discs and safety diaphragm. The filters shall be capable of absorbing any water vapor which may penetrate into the enclosures as well as the by-products of SF6 during interruption. Each gas compartment shall be fitted with non-return valve connectors for evacuating & filling the gas and checking the gas pressure etc.

16.4.27 The switchgear when installed and operating under the ambient conditions shall perform satisfactorily and safely under all normal and fault conditions. Even repeated operations up to the permissible servicing intervals under 100% rated and fault conditions, shall not diminish the performance or significantly shorten the useful life of the switchgear. Any fault caused by external/internal reasons shall be positively confined to the originating compartment and shall not spread to other parts of the switchgear.

16.4.28 The thermal rating of all current carrying parts shall be minimum for three sec. for the rated symmetrical short-circuit current.

16.4.29 The arrangement of the individual switchgear bays shall be such so as to achieve optimum space-saving, neat and logical arrangement and adequate accessibility to all external components.

16.4.30 The layout of the substation equipment, bus bars and switchgear bays shall preferably be based on the principle of “phase grouping”. Switchgear layout based on the “mixed phases” principle shall not be accepted without mutual agreement between supplier and employer.

16.4.31 The arrangement of the equipment offered must provide adequate access for operation, testing, Repair and maintenance.

16.4.32 All the elements shall be accessible without removing support structures for routine inspections. The removal of individual enclosure parts or entire breaker bays shall be possible without disturbing the enclosures of neighbouring bays and LCC panels. **To access the PT module suitable ladder shall be provided as necessary with grounding provision.**

16.4.33 It should not be possible to unwillingly touch live parts of the switchgear or to perform operations that lead to arcing faults without the use of tools or brute force. All interlocks that prevent potentially dangerous mal-operations, shall be constructed such that they cannot be operated easily, i.e. the operator must use tools or brute force to over-ride them.

16.4.34 In general the contours of energized metal parts of the GIS and any other accessory shall be such, so as to eliminate areas or points of high electrostatic flux concentrations. The surfaces shall be smooth with no projection or irregularities which may cause visible corona. No corona shall be visible in complete darkness which the equipment is subjected to specified test voltage. There shall be no radio interference from the energized switchgear at rated voltage.

16.4.35 The GIS shall be designed, so as to take care of the VFT over voltages generated as a result of pre-strikes and re-strikes during isolator operation. Maximum VFT over voltages peak shall not be higher than rated lightning impulse withstand voltage (LIWV) of the equipment. Necessary measures shall be under taken by GIS manufacture to restrict maximum VFT over voltages lower than the LIWV. Manufacturer shall submit the study report of VFTO generated for GIS installation for 220 kV and above. **The maximum value of VFT shall be controlled so that there will be no damage to SF6 to air bushing, cable termination, insulating barriers used across the flange joints of the GIS and all the other components of GIS.**

16.4.36 The enclosure shall be of continuous design and shall meet the requirement as specified in of IEEE 80 2013 (special considerations for GIS).

16.4.37 The enclosure shall be sized for carrying induced current equal to the rated current of the Bus. The conductor and the enclosure shall form the concentric pair with effective shielding of the field internal to the enclosure.

16.4.38 The fabricated metal enclosure shall be of Aluminium alloy/high grade steel having high resistance to corrosion, low electrical losses and negligible magnetic losses.

16.4.39 . The manufacturer shall clearly indicate the material used for different GIS enclosures in the GTP/design document during approval. All joint surfaces shall be machined and all castings shall be spot faced for all bolt heads or nuts and washers. All screws, bolts, studs and nuts shall confirm to metric system."The elbows, bends, cross and T-sections of interconnections shall include the insulators bearing the conductor when the direction changes take place in order to ensure that live parts remain perfectly centered and the electrical field is not increased at such points.

16.4.40 The enclosure shall be designed to practically eliminate the external electromagnetic field and thereby electro-dynamic stresses even under short circuit conditions. The average intensity of electromagnetic field shall not be more than 50 micro Tesla on the surface of the enclosure.

16.4.41 The switchgear shall have provision for connection with ground mat risers through copper connections. This provision shall consist of grounding pads to be connected to the ground mat riser in the vicinity of the equipment.

16.4.42 For 220 kV and above voltage class GIS, wherever required, stairs, fixed ladder, platforms, and walkways for operation and maintenance access to the operating mechanism and monitoring devices should be provided to permit access. The structures shall be hot-dipped galvanized steel. All structures, stairs, platforms, and walkways shall conform to the relevant occupational health and safety regulations and designed in accordance with the latest industry standards and guidelines. The platforms and walkways shall have anti-skid surfaces that can be walked on. Handrails shall be provided where necessary. **The GIS supplier shall provide 3-D arrangement drawing to show the location of equipment and access to it.**

16.4.43 In addition to above suitable portable scissor lift shall be provided for access of distant portion of GIS installation.

16.4.44 New Gasket, sealant and desiccant shall be installed for permanent sealing of all site/field assembled joints. No gaskets are to be reused for any permanent seal broken or disturbed in the field/site.

16.4.45 The enclosure & support structure shall be designed such that person of 1780 mm in height and 90 Kg in weight is able to climb on the equipment for maintenance.

16.4.46 The sealing provided between flanges of two modules / enclosures shall be such that long term tightness is achieved.

16.4.47 Alarm circuit shall not respond to faults for momentary conditions. The following indications including those required elsewhere in the specifications shall be generally provided in the alarm and indication circuits.

3.1 GAS INSULATING SYSTEM:

i) Loss of Gas Density

ii) Any other alarm necessary to indicate deterioration of the gas insulating system.

3.2 OPERATING SYSTEM:

i) Low operating pressure
ii) Loss of Heater power
iii) Loss of operating power
iv) Loss of control supply
v) Pole Discordance.

16.4.48 The equipment will be operated under the following ambient conditions (or as defined in thesection project):

a) The ambient temperature varies between 0 degree-C and 50 degree-C. However, fordesign purposes, ambient temperature should be considered as 50 degree-C.
b) The humidity will be about 95% (indoors)
c) The elevation is less than 1000 meters

16.4.49 Temperature rise of all current carrying parts and enclosures shall be limited to the values stipulated in IEC-62271-1, under rated current and the climatic conditions as specified.

16.4.50 All cabinet heaters shall be rated for 240V AC (1-phase) supply and shall be complete with thermostat, control switches and fuses, connected as a balanced 3-phase 4-wire load. The heaters shall be so arranged and protected as to create no hazard to adjacent equipment from the heat produced.

Expansion Joints and Flexible Connection

Expansion and installation alignment shall be considered in the design of the bus and enclosure. The continuity of service during thermal expansion / contraction and vibrations shall be ensured. The switchgear shall be fixed to the floor with minimum requirement on floor preparation. If required, expansion joints shall be provided with compensator for the enclosure and sliding plug-in contacts for the conductors. Expansion joints and flexible connections shall be considered in the design of the bus and enclosure to take care of thermal expansion / contraction and vibrations during service and to absorb the relative movement between the switchgear equipment and its fixing structure / floor. The position of expansion joints or flexible connections are to be considered by the manufacturer to ensure that the complete installation will not be subject to expansion stresses which could lead to distortion or failure of any piece of the SF6 equipment, support structures or foundations. These expansion joints shall be provided with each bay, which will provide maximum tolerance and the flexibility during the installation & maintenance.

Also, expansion joints, flexible connections and adjustable mountings shall be provided to compensate for reasonable manufacturing and construction tolerances in the associated equipment to which the GIS may be connected. Flexible joints may also be provided to allow more efficient maintenance and future extensions of the GIS.

16.4.51 **Bellows or Compensating Units:-** Adequate provision shall be made to allow for the thermal expansion of the conductors & enclosures and for differential thermal expansion between the conductors and the enclosures. The bellows metallic(preferably stainless steel) with suitable provision for permitting the movement during expansion and contraction maybe provided and shall be of following types:.

1. Lateral / Vertical mounting units: These shall be inserted, as required, between sections of busbars, on transformer, shunt reactor and XLPE cable

etc. Lateral mounting shall be made possible by a sliding section of enclosure and tubular conductors.

2. Axial compensators: These shall be provided to accommodate changes in length of busbars due to temperature variations.
3. Parallel compensators: These shall be provided to accommodate large linear expansions and angle tolerances.
4. Tolerance compensators: These shall be provided for taking up manufacturing, site assembly and foundation tolerances.
5. Vibration compensators: These bellow compensators shall be provided for absorbing vibrations caused by the transformers and shunt reactors when connected to SF6 switchgear by oil- SF6 bushings.

The electrical connections across the bellows or compensating units shall be made by means of suitable connectors. For sliding type compensators, markers/pointers shall be provided to observe expansion or contraction during climatic conditions.

16.4.52 **Indication and verification of switch positions**: Indicators shall be provided on all circuit breakers, isolators and earth-switches, which shall clearly show whether the switches areopen or closed. The indicators shall be mechanically coupled directly to the main contact operating drive rod or linkages and shall be mounted in a position where they are clearly visible from the floor or the platform in the vicinity of the equipment.

Inspection windows shall also be provided with all isolators and earth switches so that the switch contact positions can be verified by direct visual inspection.

16.4.53 **Pressure relief device** : Pressure relief devices shall be provided in the gas sections to protect the gas enclosures from damage or distortion during the occurrence of abnormal pressure increase or shock waves generated by internal electrical fault arcs (preferably in downward direction).

Automatic external pressure relief devices shall be incorporated in the basic design as a precaution against bursting of enclosure. Internal pressure relief devices shall not be acceptable. The bursting pressure of the relief device shall be effectively coordinated with the rated gas pressure and the pressure rise due to arcing to avoid any mal-operation in normal operating conditions. Deflection devices shall be installed to ensure that personnel will not be endangered. Pressure relief shall be by means of a metallic bursting disc system with a preset opening pressure. For better gas tightness, bursting discs made of graphite or non-metallic material shall be avoided.

Pressure relief shall be achieved either by means of diaphragms or plugs venting directlyinto the atmosphere in a controlled direction.

If the pressure relief devices vent directly into the atmosphere, suitable guards and deflectors shall be provided.

16.4.54 **Pressure vessel requirements**: The enclosure shall be designed for the mechanical and thermal loads to which it is subjected in service. The enclosure shall be manufactured and tested according to the Pressure Vessel Code (ASME/CENELEC code for pressure Vessel.)
The bursting strength of Aluminum castings has to be at least 5 times the design pressure. A bursting pressure test shall be carried out at 5 times the design pressure as a type test on each type of enclosure.

Each enclosure has to be tested as a routine test at 1.5 times the design pressure for one minute.The metal enclosures for the GIS equipment modules shall be made from Aluminum alloy and tubular in construction. The tenderer shall state the material used for his particular design. All flanges shall be directly bolted together with good metallic contact to make enclosures equipotential.

Enclosures shall withstand normal and transient pressure in operation. They shall be designed and manufactured according to the related standards to safety and reliability of material, construction, welding technology and testing. Enclosures shall be designed to withstand any internal arc specified in IEC 62271-203.

The gas-filled enclosures shall comply to the pressure vessel code applied in the country of manufacturer and shall be suitable for purchaser's environmental condition.

16.4.55 GROUNDING:

16.4.43.1 The grounding system shall be designed and provided as per IEEE-80-2013 and CIGRE-44 to protect operating staff against any hazardous touch voltages and electro-magnetic interferences.

16.4.43.2 The GIS supplier shall define clearly what constitutes the main grounding bus of the GIS. The contractor shall supply the entire material for grounding bus of GIS viz conductor, clamps, joints, operating and safety platforms etc. The contractor is also required to supply all the earthing conductors and associated hardware material for connecting all GIS equipment, bus ducts, enclosures, control cabinets, supporting structure, GIS surge arrestor etc. to the ground bus of GIS.

16.4.43.3 The enclosure of the GIS may be grounded at several points so that there shall be grounded cage around all the live parts. A minimum of two nos. of grounding connections should be provided for each of circuit breaker, current transformers, voltage transformers, cable terminals, surge arrestors, earth switches and at each end of the bus bars. The grounding continuity between each enclosure shall be effectively interconnected either internally or externally with Copper bonds of suitable size to bridge the flanges. Subassembly to subassembly bonding shall be provided to bridge the gap & safe voltage gradients between all intentionally grounded parts of theGIS assembly & between those parts and the main grounding bus of the GIS.

16.4.43.4 Each marshalling box, local control panel, power and control cable sheaths and other non- current carrying metallic structures shall be connected to the grounding system of GIS via connections that are separated from GIS enclosures.

16.4.43.5 The grounding connector shall be of sufficient mechanical strength to withstand electromagnetic forces as well as capable of carrying the anticipated maximum fault current without overheating. At least two grounding paths shall be provided to connect each point to the main grounding bus. Necessary precautions should be under taken to prevent excessive currents from being induced into adjacent frames, structures of reinforcing steel and to avoid establishment of current loops via other station equipment.

16.4.43.6 All flexible bonding leads shall be tinned copper. All connectors, for attaching flexible bonding leads to grounding conductors and grounding conductors to support structures shall be tinned bronze with stainless steel or tinned bronze hardware.

The enclosure grounding system shall be designed to minimize circulating currents and to ensure that the potential rise during an external or internal fault is kept to an acceptable level. The guidelines of IEEE Std. 80-2000 on GIS grounding, especially the transient ground potential rise caused by high frequency phenomena, shall be taken into consideration while designing the grounding system for GIS. The manufacturer shall furnish readily accessible connectors of sufficient mechanical strength to withstand electromagnetic forces as well as capable of carrying the anticipated maximum fault current without overheating by at least from two paths to ground from the main ground bus. The contractor shall provide suitable measure to mitigate transient enclosure voltage caused by high frequency currents due to by lightning strikes, operation of surge arrestor, phase to earth fault and discharges between contacts during switching operation. The grounding system shall ensure safe touch & step voltages in all the enclosures. The manufacturer shall provide suitable barrier of non-linear resistor/counter discontinued SF6/Air termination SF6/HV cable bushing etc. to mitigate transient enclosure voltage.

a) Earthing of Main Circuits

To ensure safety during maintenance work all parts of the main circuit, to which access is required, shall be provided with facilities for connecting removable earthing device, after opening the enclosure, on the circuit element which is previously earthed via main earth switch.

b) Earthing of Enclosure

The enclosure shall be connected to earth. All metal parts other than main and auxiliary circuits shall be earthed. Separate earthing strips to short circuit flanges and earth switches are not allowed. Earthing switches shall be connected to earth through enclosures. Individual earth leads for the earth Switches are not recommended. The continuity of the earthing circuits shall be ensured taking into account thermal and electrical stresses caused by the current they have to carry. Each of the earthing strips shall be connected to the main earthing mesh installed below the GIS, at two ends.

c) Earthing of GIS

The earthing system shall be based on a multi-point design ensuring the protection in case of indirect contact (Touch or step voltages, in case of system fault) and transient phenomena in case of lightning or switching operations.

Earthing conductors shall allow fault with short circuit current for at least 3 sec. Separate ground strips to short circuit flanges and earthing switches are not allowed. Grounding switches shall be connected to ground through the enclosure. Individual ground leads for the ground switches are not allowed.

Notes: EARTHING CONDUCTOR SHALL BE OF COPPER AND SIZE MAY VARY AS PER EARTHING CALCULATION AND THE SAME WILL BE DECIDED DURING DETAILED ENGINEERING. The GIS manufacturer shall furnish earthing design calculations with touch voltage limited to 65V.
Corrosion factor shall be taken into consideration while performing earthing design calculations.

Equipotential Earthmat: (below the GIS)

When a fault current flows through the earthing connections into the soil, the enclosures, linked to the earthing circuits, are carried at the same potential as the earthing mat conductors but this potential is generally different from that on the soil surface.

In order to ensure the security of personnel, it is necessary to install an equipotential mat linked to the general earthing mat in the zones where metal enclosures and fixed accessories are accessible from the floor.

It is also necessary to provide an equipotential earthing mat in the zones where an emergency mechanical operation or a locking system is accessible from the floor. It is therefore possible to extend the equipotential mat to allow the operator to carry out his manoeuvres.

In order to ensure a good equipotential surface, each element of the equipotential mat must be connected to the general earthing network by the manufacturer.

This mat will be placed on the floor, all around the switch gears. It is not required in front of the control cubicles. If it is an oxidizing material, it should be hot dip galvanized.

The manufacturer must provide and specify this equipotential earthing mat. The location of the equipotential mat should be defined by the supplier for all the GIS and at places where:

-the enclosures are accessible for the floor.

-Manual operation of apparatus or locking system is located.

Five copies of equipotential earth mat drawings along with design calculations may be submitted for approval by the successful Tenderer.

16.4.56 **UHF SENSORS FOR PD DETECTION**:
Adequate number of UHF sensors shall be provided in the offered GIS for detection of Partial discharge up to 5 PC as per IEC 60270. The number and location of these sensors shall be based on laboratory test on typical design of GIS as per recommendations of CIGRE Document No. 654 (*APPLICATION GUIDE FOR SENSITIVITY VERIFICATION for UHF PARTIAL DISCHARGE DETECTION SYSTEM FOR GIS*) and CIGRE task force TF15/33.03.05 (Task force on Partial discharge detection system for GIS: Sensitivity verification for the UHF method and the coustic method). Offered numbers and location of UHF sensors shall be submitted based on above said criteria along with attenuation calculation for approval of the employer. Further UHF sensors shall necessarily be provided in close proximity to VT compartments, Bus bar compartment, SF6 to air bushing, cable termination compartment based on proven range of detection of partial discharge to be indicated in SF6 gas partition drawing.
However adequacy of number of sensors and their location shall be verified at site as per recommendations of above CIGRE Document No. 654. In case during site testing, additional UHF sensors are required, the same shall also be supplied & installed to complete the technical requirement.

The calibration and frequency response of PD couplers shall be as per NGC Technical Guidance note TGN (T) 121, issue 1, 1997. **Data sheet shall be submitted for the UHF couplers meeting this requirement.**

Finish of Surface and Cleaning

The finish of interior surfaces of the GIS enclosures shall facilitate cleaning and inspection. Any paints or other coatings that may be used shall not deteriorate when exposed to the SF6 gas and arc products, etc., that may be present in the enclosures. They shall not contain any substances which could contaminate the enclosed SF6 gas or affect its insulating properties over a period of time.

The equipment shall be manufactured and assembled at the manufacturer's works under conditions of the utmost cleanliness. Before factory tests and packing for shipment, interior surfaces, insulators, barriers etc., must be thoroughly cleaned.

Supporting Structures

All supporting structures necessary for the support of the GIS equipment including associated parts such as anchor bolts, beams etc. shall be supplied.

All the Anchor Bolts to be used in the GIS Shall be chemically galvanised.

Access has to be considered in the design of the structures to all equipment of the GIS. It has to be possible to surround the GIS with the gas cart.

The specified stresses for outdoor equipment like wind, earthquake, snow, ice and thermal expansion due to current and sun radiation have to be considered.

Proper surface treatment for all parts especially in outdoor situation has to be considered. All steel members have to be hot-dipped galvanized (indoor structures: 90 microns; outdoor structures: 130 microns) according to relevant Indian/International standards for heavily polluted environment.

Auxiliary Contacts

Each equipment shall be furnished with adequate number of electrically independent contacts at user's disposal. They shall be wired to terminals located in the local control cabinet of the circuit breaker bay. Installation of auxiliary relays (contact multiplication) may be used to meet the overall control and protection requirements.

16.4.57 GAS INSULATED BUS (GIB) LAYOUT :

GIB shall be designed based on the following criteria

(1) Maximum weight of gas in a gas tight section of GIB shall not exceed 400 Kg (for 400 kV)/ 250 Kg (for 220 kV & 132 kV).

(2) GIB shall be generally in horizontal layer. However in exceptional circumstance GIB in vertical layers with suitable support structures can be provided with the approval of AEGCL.

(3) The minimum vertical ground clearance of GIB at road crossing shall be 5.5 meters

(4) The horizontal clearance between GIB and GIS building /any other building wall shall be preferably three (3) meters.

(5) The GIB route inside the GIS Hall shall not obstruct easy access to GIS and control room buildings and shall not obstruct movement of crane, equipment including HV test equipment for maintenance works.

(6) The GIB clear height outside the GIS hall in switchyard area shall be minimum 3.5 meter, so as not to obstruct easy access to GIB, movement of crane for maintenance work.

(7) Optimization of outdoor GIB length using overhead AIS connection with Bus Post Insulator of respective voltage class is generally acceptable subject to meeting the electrical clearances as stipulated.

(8) For the maintenance of GIB of one circuit, only that circuit shall be isolated. Adequate clearance between bus ducts of two circuit shall be ensured by the contractor during layout finalization.

(9) GIS manufacturer as per their design shall preferably use maximum three standard straight horizontal outdoor bus duct lengths for entire GIS installation to optimize the spare requirement.

(10) Special anti-corrosive measures shall be taken in bus ducts as per site condition.

16.4.58 EXTENSION OF GIS

16.4.46.1 The arrangement of gas sections or compartments shall be such as to facilitate future extension of any make without any drilling, cutting or welding on the existing equipment. To add equipment, it shall not be necessary to move or dislocate the existing switchgear bays.

16.4.46.2 As the GIS is likely to be extended in future, during detailed engineering stage, the contractor shall make available the complete design detail of interface module such as cross section, enclosure material, enclosure dimensions (inner & outer), Flange diameter (inner & outer), conductor cross-section & connection arrangement, bolt spacing & dimension, rated gas pressure, Gasket detail etc. Further GIS manufacturer supplying GIS under present scope shall furnish all the required details in addition to above, necessary for design and successful implementation of an interface module during later stage while extending GIS by any other GIS manufacturer, without any help of GIS manufacturer who has supplied the GIS equipment in present scope. For 400kV GIS, in case one additional bay is required, the supplier has to provide all equipment necessary for the complete diameter with extension links kept outside the GIS building for future use.

16.4.46.3 The Interface module shall be designed to provide Isolating link with access hole on enclosure. The Isolating link shall be provided in such a way so that HV test can be performed on either side of the interface module separately, keeping other side of GIS remained isolated. Interface Module drawing with necessary detail shall be submitted for approval.

16.4.46.4 Further the contractor who is extending the existing GIS installation, it shall be his responsibility to provide interface module matching with the existing GIS interface module. The drawing of existing GIS interface/end piece module shall be provided by the employer. However it shall be the responsibility of contractor to verify the existing details during site visit.

The Contractor shall optimally utilize the space inside the GIS hall (including the extension portion) for accommodating the interface module being supplied under the contract.

For any type of bus bar configuration, it shall be possible to extend the switchgear by adding future feeders as decided by the owner with at least one of the bus bar systems in service continuously and the existing feeders remaining in service continuously. The Vendor is required to demonstrate clearly in his submitted documents the suitability of the switchgear design in this respect.

16.4.59 **SF6 GAS**

The tender shall include the supply of all SF6 gas necessary for filling and putting in commercial operation the complete switchgear installation with recommended extra quantity (minimum 10% extra). The SF6 gas insulated metal-clad switchgear shall be designed for use with SF6 gas complying with the recommendations of IEC 60376, 60376A & 60376B, at the time of the first charging with gas. All SF6 gas supplied as part of the contract shall comply with the requirements of IEC & should be suitable in all respects for use in the switchgear under all operating conditions.. Necessary statutory clearances from concerned authorities for import of the Gas and for storage of the Gas shall be obtained.

The high pressure cylinders in which SF6 gas is supplied & stored at site shall comply with the requirements of following standards & regulations:

IS : 4379 Identification of the contents of industrial gas cylinders.

IS : 7311 Seamless high carbon steel cylinders for permanent & high pressure liquefiable gases. The cylinders shall also meet latest Gas Cylinder Rules (PESO) SF6 gas shall be tested for purity, dew point, air, hydrolysable fluorides and water contents as per IEC:60376, 60376A& 60376B and test certificates shall be furnished to the Employer indicating all test results as per IEC standards for each lot of SF6 gas SF6 gas shall be tested for purity, dew point, air, hydrolysable fluorides and water contents as per IEC:60376, 60376A& 60376B and test certificates shall be furnished to the Employer indicating all test results as per IEC standards for each lot of SF6 gas. Further site tests for dew point and purity shall be done during commissioning of GIS. **Gas bottles should be tested for leakage during receipt at site.**The contractor shall indicate diagnostic test methods for checking the quality of gas in the various sections of GIS during service. The method proposed shall have as a minimum check the moisture content & the percentage of purity of the gas on annual basis.

Spare SF6 cylinders shall be provided with Gas preservation system.

The contractor shall also submit clearly the precise procedure to be adopted by maintenance personnel for handling equipment that are exposed to the products of arcing in SF6 Gas soas to ensure that they are not affected by possible irritants of the skin and respiratory system. Recommendations shall be submitted for suitable protective clothing, method of disposal of cleaning utensils and other relevant matters.

The contractor shall also indicate the details and type of filters used in various gas sections, and should also submit the operating experience with such filters.

SF6 gas monitoring devices and alarm circuits: Dial type temperature compensated gas density monitoring devices with associated pressure gauge will be provided. The devicesshall provide continuous & automatic (ONLINE) monitoring of gas density. A separate device shall be provided for each gas tight compartment so that it can be monitored simultaneously as follows:-

Compartment/ Sl. No.	Compartments except CB	Circuit Breaker compartments
1	**“Gas Refill level:** This will be used to annunciate the need for the gas refilling. The contractor shall provide a contact for remote indication to SAS.	**'Gas Refill' level :**This will be used to annunciate the need for gas refilling. The contractor shall provide a contact for remote indication to SAS.
2	**“SF6 low level” :** This will be used to annunciate the need for urgent gas filling . A contact shall be provided for remote indication to SAS	**“SF6 low level” :** This will be used to annunciate the need for urgent gas filling . A contact shall be provided for remote indication to SAS
3	**'Zone Trip' level:** This is the minimum level at which the manufacturer will guarantee the insulation rating of the assembly.	**Breaker Block' level :** This is the minimum gas density at which the manufacturer will guarantee the rated fault interrupting capability of the breaker. At this level the breaker block contact shall operate and the closing & tripping circuit shall be blocked. A contact shall be provided for remote indication to SAS
4	**Not Applicable**	**'Zone Trip' level:** This is the minimum level at which the manufacturer will guarantee the insulation rating of the assembly.

The density monitor/pressure switch contacts shall be in accordance with the above requirement.

It shall be possible to test all gas monitoring relays/devices without de-energizing the primary equipment & without reducing pressure in the main section. It shall also damp the pressure pulsation while filling the gas in service, so that flickering of the pressure switch contacts does not take place.

Gas Supply: The contractor shall include the supply of all SF6 gas necessary for filling & putting into operation the complete switchgear installation being supplied. The empty gas cylinders shall be returnable to the contractor.

16.4.60 **DOCUMENTATION**

The contractor shall prepare and submit to the employer, drawings, details that show the GIS design in order for the employer to verify the equipment conform to the specifications. The Design Document to be submitted for review and approval are as follows:

i. Design Review Document
ii. Single Line Diagram
iii. Gas Schematic Diagram
iv. GTP-Guaranteed Technical Particulars

v. GIS layout (Plan and Section) including 3D drawing

vi. GIS Component Drawings

vii. Interface modules drawing for GIS extension

viii. Rating and Name Plate Drawing

ix. GIS/LCC Schematics Drawing

x. Foundation loading plan and detail

xi. GIS Support Structure Drawing

xii. GIS platforms and Walkway Drawing

xiii. GIS grounding plan and details along with design calculation for GIS grounding

xiv. GIS key Diagram enlisting and marking each and every GIS Module clearly and separately identifiable (indoor and outdoor). This separately identified module shallbe complete along with its enclosure, gasket and all active parts such as conductor, conductor joints, corona shield etc.

xv. Method Statement along with sequential instruction for dismantling and assembling of all major components of GIS exhibiting service continuity requirement

xvi. Type Test Reports

xvii. Seismic Analysis Report

xviii. Study report of VFTO generated for GIS installation for 400 kV and above.

xix. The general arrangement drawing of interconnecting bus-duct from GIS bay moduleto XLPE cable termination end

xx. The general arrangement drawing of Terminal connection arrangement to connectGIS duct to SF6/Oil bushing and duct mounting arrangement details

xxi. Gas handling procedure

xxii. The design & construction proposal of the building along with necessary information, data, and drawings according to the complete requirements

xxiii. Capacity calculation of EOT crane for GIS hall considering a factor of safety of 5

xxiv. Method statement/ procedure of ON SITE high voltage testing with PD measurementand Switching Impulse test

xxv. Additional CB data to be furnished during detailed engineering :

a) Design 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.
b) Curves supported by test data indicating the opening time under close open operation with combined variation of trip coil voltage and hydraulic pressure.
c) Contact Travel: Operating mechanism operating shaft travel and contact overlapof Circuit Breaker to be provided

xxvi. PD Monitoring System The technical proposal for PDM system along with detailed design documentation.

a) Data sheet for the UHF couplers.
b) The Sub-station GIS layout as a separate drawing indicating position of spacers, spread over of PD sensors with distance, sensor identification, the detector unit identification etc., total numbers of offered UHF Sensors along with attenuation calculation.
c) Guaranteed Technical Particulars & Data Sheet for various components used in the PDM system.
d) Electromagnetic compatibility Test Reports.
e) List of critical spares.

xxvii. Installation and Operation & Maintenance Manual
xxviii) Temperature rise calculation of the GIS alongwith the thermal expansion data
xxix) Insulation coordination report
xxx) Transfer surge calculation with respect to GIS connection with transformer & reactor

16.5 TECHNICAL SPECIFICATION OF THE HIGH VOLTAGE COMPONENTS OF GIS

16.5.1 CIRCUIT BREAKERS

16.5.1.1 **General :** SF6 gas insulated metal enclosed circuit breakers and accessories shall conform to IEC: 62271-100, IEC: 62271-1 and other relevant IEC standards except to the extent explicitly modified in the specification .

16.5.1.2 Circuit breakers shall be equipped with the operating mechanism. **Circuit breakers shall be of single pressure pufferred type design**. Complete circuit breaker with all necessary items for successful operation shall be supplied. The circuit breakers shall be designed for high speed single and three phase reclosing (as applicable) with an operating sequence and timing as specified.

Duty Requirements: Circuit breaker shall be C2 - M2- E2 class as per IEC 62271-100.
Circuit breaker shall meet the duty requirements for any type of fault or fault location also for line charging and dropping when used on effectively grounded system and perform make and break operations as per the stipulated duty cycles satisfactorily.
Pre insertion resister: 400 kV circuit breakers for line bay (as per the provisions of bid proposal sheet) shall be provided with single step pre insertion closing resistors (wherever the requirement of PIR is explicitly specified so) to limit the switching surges to a value of less than 2.3 p.u for 400kV. PIR contacts should open immediately after closing of main contacts or At least 5 ms prior to opening of main contacts at rated air/gas pressure where the PIR contacts remain closed. The resistor shall have thermal rating for the following duties :
Terminal fault : Close.... 1 Min........ Open...... Close Open 2 min........ Close ....
1 Min Open Close Open.

Reclosing against trapped charges : Duty same as under (a.) above. The first, third and fourth closures are to be on de-energised line while second closing is to be made with lines against trapped charge of 1.2 p.u. of opposite polarity.

Out of phase closing: One closing operation under phase opposition that is with twice the voltage across the terminals.

No allowance shall be made for heat dissipation of resistor during time interval between successive closing operations. The resistors and resistor supports shall perform all these duties without deterioration. Calculations and test reports of resistors proving thermal rating for duties specified above shall be furnished during detailed engineering. The calculations shall take care of adverse tolerances on resistance values and time settings.

The circuit breaker shall be capable of: Interrupting the steady and transient magnetizing current shall be as follows:

Voltage Level	Type of Transformer	Rating (in MVA)
400kV	400/220kV	250 to 630
	400/132kV	160 to 315
220kV	400/220kV	250 to 630

	220/132kV	50 to 200
132kV	220/132kV	50 to 200
	132/33kV	10 to 50

a) Interrupting line/cable charging/capacitive current as per IEC without re-strikes and without use of opening resistors.. The breaker shall be able to interrupt the rated line charging current as per IEC-62271-100 with test voltage immediately before opening equal to the product of U/□3 and 1.4

b) Clearing terminal fault (100%) & short line fault (Kilometric faults) with source impedance behind the bus equivalent to symmetrical fault current specified.

c) Breaking 25% the rated fault current at twice the rated voltage under phase opposition condition.

d) The breaker shall satisfactorily withstand the high stresses imposed on them during fault clearing, load rejection and re-energisation of shunt reactor and/or series capacitor compensated lines with trapped charges.

e) Withstanding all dielectric stresses imposed on it in open condition at lock out pressure continuously (i.e. shall be designed for 2 p.u. across the breaker continuously, for validation of which a power frequency withstand test conducted for a duration of atleast 15 minutes is acceptable).

f) Circuit breakers shall be able to switch in and out the shunt reactor as detailed below:

Voltage Level	**Reactor Rating (in MVAR)**	**Max. rise of overvoltage(in p.u.)**
400Kv	**50 to 150**	**2.3**
220kV	**25 to 50**	**2.3**

16.5.1.3 **Total Break Time :**The total break time shall not be exceeded under any of the following duties :

a) Test duties T10,T30,T60,T100 (with TRV as per IEC- 62271-100)

b) Short line fault L90, L75 (with TRV as per IEC-62271-100)

please note that total break time of the breaker shall not be exceeded under any duty conditions specified such as with the combined variation of the trip coil voltage (70-110%), pneumatic/hydraulic pressure and SF6 gas pressure etc. While furnishing the proof for the total break time of complete circuit breaker, the contractor may specifically bring out the effect of non-simultaneity between poles and show how it is covered in the total break time.

The values guaranteed shall be supported with the type test reports.

16.5.1.4 CONSTRUCTIONAL FEATURES :

The features and constructional details of breakers shall be in accordance with requirements stated hereunder:

16.5.1.7.1 If multi-break interrupters are used, these shall be so designed and augmented that a uniform voltage distribution is developed across them. Calculations/ test reports in support of the same shall be furnished. The thermal and voltage withstand rating of the grading elements shall be adequate for the service conditions and duty specified.

16.5.1.7.2 Contacts: All making and breaking contacts shall be sealed and free from atmospheric effects. Contacts shall be designed to have adequate thermal and current carrying capacity for the duty specified and to have a life expectancy so that frequent replacement due to excessive burning will not be necessary. Provision shall be made for rapid dissipation of heat generated by the arc on opening.

16.5.1.7.2 Any device provided for voltage grading to damp oscillations or, to prevent re-strike prior to the complete interruption of the circuit or to limit over voltage on closing, shall have a life expectancy comparable of that of the breaker as a whole.

16.5.1.7.3 Breakers shall be so designed that when operated within their specified rating, the temperature of each part will be limited to values consistent with a long life for the material used. The temperature rise shall not exceed that indicated in IEC-62271-100 under specified ambient conditions.

16.5.1.7.4 The breaker should be able to withstand all dielectric stresses imposed on it in open condition at lockout pressure continuously (i.e. 2 p.u. power frequency voltage across the breaker continuously)

16.5.1.7.5 In the interrupter assembly there shall be an adsorbing product box to minimize the effect of SF6 decomposition products and moisture. The material used in the construction of the circuit breakers shall be such as to be fully compatible with SF6 gas decomposition products.

16.5.1.7.6 Provisions shall be made for attaching an operational analyzer to record travel, speed and making measurement of operating timings etc. after installation at site. The contractor shall supply three set of transducer for each substation covered under the scope.

16.5.1.7.7 Circuit Breaker shall be supplied with auxiliary switch having additional 10 NO (normally open) and 10 NC (normally closed) contacts for future use over and above those required for switchgear interlocking and other control and protection function. These spare NO and NC contacts shall be wired upto the local control cubicle.

16.5.1.7.8 The CO (Close-open) operation and its timing shall be such as to ensure complete travel/insertion of the contact during closing operation and then follow the opening operation.

16.5.1.7.9 The bidder has to verify whether the offered insulation level of the line end breakers is adequate for the respective transmission lines or not.

16.5.1.5 OPERATING MECHANISM

16.5.1.8.1 **General Requirements:**

a) Circuit breaker shall be operated by spring charged mechanism or hydromechanical spring mechanism.

b) The mechanism shall be housed in a dust proof cabinet and shall have IP: 55 degree of protection.

c) The operating mechanism **box** shall be strong, rigid, rebound free and shall be readily accessible for maintenance.

d) The operating mechanism shall be suitable for high speed reclosing and other duties specified. During reclosing the breaker contacts shall close fully and then open. The mechanism shall be anti-pumping and trip free (as per IEC definition) under every method of closing.

e) The mechanism shall be such that the failure of any auxiliary spring will not prevent tripping and will not cause unwanted trip or closing operation of the Circuit Breaker.

f) 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. **A non-resettable operation counter shall also be provided.**

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

h) The contractor shall furnish detailed operation and maintenance manual of the mechanism along with the operation manual for the circuit breaker.

i) The duty cycle for the CB shall be O-0.3s-CO-3 min-CO.

16.5.1.6 CONTROL

a) The close and trip circuits shall be designed to permit use of momentary-contact switches and push buttons.

b) Each breaker pole shall be provided with two (2) independent tripping circuits and trip coils which may be connected to a different set of protective relays.

c) The breaker shall normally be operated by remote electrical control. Electrical tripping shall be performed by shunt trip coils. However, provisions shall be made for local electrical control. For this purpose a local/remote selector switch and close and trip control switch shall be provided in the breaker control cabinet.

d) The trip coil shall be suitable for trip circuit supervision during both open and close position of breaker.

e) Closing coil and associated circuits shall operate correctly at all values of voltage between 85% and 110% of the rated voltage. Shunt trip and associated circuits shall operate correctly under all operating conditions of the circuit breaker upto the rated breaking capacity of the circuit breaker and at all values of supply voltage between 70% and 110% of rated voltage.

f) Density meter contacts and pressure switch contacts shall be suitable for direct use as permissive in closing and tripping circuits. Separate contacts have to be used for each of tripping and closing circuits. If contacts are not suitably rated and multiplying relays are used then fail safe logic/schemes are to be employed. DC supplies shall be monitoredfor remote annunciations and operation lockout in case of dc failures.

g) The auxiliary switch of the breaker shall be positively driven by the breaker operatingrod.

16.5.1.7 SPRING OPERATED MECHANISM (SPRING-SPRING)

a) Spring operated mechanism shall be complete with motor as per manufacturer practice. Opening spring and closing spring with limit switch for automatic charging and other necessary accessories to make the mechanism a complete operating unit shall also be provided.

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

c) After failure of power supply to the motor one O-CO operation shall be possible with the energy stored in the operating mechanism.

d) Breaker operation shall be independent of the motor which shall be used solely for compressing the closing spring. Facility for manual charging of the closing spring shall also be provided. The motor rating shall be such that it required preferably not more than 90 seconds for full charging of the closing spring.

e) Closing action of circuit breaker shall compress the opening spring ready for tripping.

f) When closing springs are discharged after closing a breaker, closing springs shall automatically be charged for the next operation and an indication of this shall be provided in the local control cabinet & SAS .

g) Provisions shall be made to prevent a closing operation of the breaker when the spring is in the partial charged condition.

h) Mechanical interlocks shall be provided in the operating mechanism to prevent discharging of closing springs when the breaker is in the closed position.

i) The spring operating mechanism shall have adequate energy stored in the operating spring to close and latch the circuit breaker against the rated making current and also to provide the required energy for the tripping mechanism in case the tripping energy is derived from the operating mechanism.

j) The spring charging failure alarm shall be provided with a time delay relay having setting range from 0-3 minutes.

k) Separate MCBs shall be provided for each spring charging motor and the rating of MCBs shall be suitably selected to match the starting, running and stalling time.

l) An overload relay shall be provided for protection of the spring charging motor.

16.5.1.8 CONTROLLED SWITCHING DEVICE (CSD):

16.5.1.11.1 400KV Circuit Breaker shall be equipped with controlled switching device with consequent optimization of switching behavior, when used in:

1. Switching of transformer (from 400kV side circuit breakers only). **CSD application for 220kV transformer switching shall also be evaluated as per the SLD requirement.**
2. Switching of line and bus reactor.
3. Switching of line (>200km) CSD will be preferred to PIR

16.5.1.11.2 The CSD shall be provided in 400kV Circuit breakers for controlling transformers and reactors (ie for breakers of switchable line reactor and in Main& Tie circuit breakers of Transformers, Transmission lines with non-switchable line reactors and Bus reactors). The requirement of CSD shall be explicitly specified in price schedule

16.5.1.11.3 Technical Requirement for Controlled switching device:

a) The CSD shall be designed to operate correctly and satisfactorily with the excursion of auxiliary A/C & DC voltages and frequency as per requirement.
b) The CSD shall meet the requirements of IEC-61000-4 16 class IV regarding HF disturbance test and fast transient test shall be as per IEC-61000 – 4-4 level IV and insulation test as per 60255 – 5.
c) The CSD shall have functions for switching ON & OFF the circuit breakers.
d) The CSD shall get command to operate the breakers manually or through auto re- close relay at random. The controller shall be able to analyze the current and voltage waves available through the signals from secondaries of CTs & CVTs for the purpose of calculation of optimum moment of the switching the circuit breaker and issue command to circuit breaker to operate.
e) The CSD shall have an adaptive control feature to consider the next operating time of the breaker in calculation of optimum time of issuing the switching command. In calculation of net operating time of the breaker the controller must consider all factors that may affect the operating time of the breaker such as, but not limited to, ambient temperature, control voltage variation, SF6 gas density variations etc. Schematic drawing for this purpose shall be provided by the contractor. The accuracy of the operating time estimation by the controller shall be better than + 0.5 ms.
f) The CSD shall have communication port to facilitate online communication of the control switching device with SCADA directly on 61850 or through gateway which shall be under present scope.
g) The CSD shall be PC compatible for the setting of various parameters and down loading of the settings and measured values date time of switching etc. Window based software for this purpose shall be supplied by the contractor to be used on the owner’s PC.

h) The CSD shall be suitable for current input of 1 amp from the secondary of the CTs. and 110 V (Ph to Ph) from the CVTs. The controller shall withstand transient and dynamic state values of the current from the secondary of the CTs and CVTs.

i) The CSD shall have time setting resolution of 0.1 ms or better.

j) The CSD shall have sufficient number of output/input potential free contacts for connecting the monitoring equipment and annunciation system available in the control room. Necessary details shall be worked out during engineering the scheme.

k) The CSD shall also record and monitor the switching operations and make adjustments to the switching instants to optimize the switching behavior as necessary. It shall provide self-diagnostic facilities, signaling of alarms and enable downloading of data captured from the switching events.

l) The provision for bypassing the Controlled switching device shall be provided through BCU and SCADA both so that whenever, the CSD is not healthy due to any reason (including auxiliary supply failure), uncontrolled trip/close command can be extended to the circuit Breaker. Alternatively, in case of any non-operation of the CSD after receiving a close/trip command after a pre-determined time delay, the CSD should automatically be bypassed so as to ensure that the trip and close commands are extended to the Trip/Close coils through subsequent command.

m) The CSD shall be provided with a communication port to facilitate online communication of the CSD with Substation automation system directly on IEC 61850 protocols. If the CSD does not meet the protocols of IEC 61850, suitable gateway shall be provided to enable the communication of CSD as per IEC 61850.

16.5.1.9 TESTS :

Type Tests:

i. The circuit breaker along with its operating mechanism shall conform to the type tests as per IEC-62271- 100.

ii. The type test report of Electromagnetic Compatibility Test (EMC) of CSD shall be submitted for approval

iii. Circuit breakers meant for controlled switching shall conform to requirements of IEC/TR-62271–302. The contractor shall submit test reports to demonstrate that the offered CB conforms to the requirements of performance verification tests and parameter definition tests as per IEC/TR 62271-302. The contractor shall also furnish the report for the re-ignition free arcing window for switching 3-phase shunt reactor as demonstrated in the shunt reactor switching test.

16.5.1.10 ROUTINE TESTS:

Routine tests as per IEC: 62271-100 shall be performed on all circuit breakers. In addition to the mechanical and electrical tests specified by IEC, the following shall alsobe performed.

i. Speed curves for each breaker shall be obtained with the help of a suitable operation analyzer to determine the breaker contact movement during opening, closing, auto reclosing and trip free operation under normal as well as limiting operating **control** voltage conditions. The tests shall show the speed of contacts directly at various stages of operation, travel of contacts, opening time, closing time, shortest time between separation and meeting of contacts at break make operation etc. This test shall also be performed at site for which the necessary operation analyzer along with necessary transducers, cables, console etc. shall be **arranged by the contractor at his** own cost. After completion of site pre-commissioning test, 03 nos. travel transducer shall be handed over to AEGCL.

ii. During testing of CB, dynamic contact resistance measurement (DCRM) shall be carried out for close-open (CO) operations with delay of 300ms between close and trip operations. Minimum 100A current shall be injected for DCRM test. Travel characteristics, injected current, trip/close coil current shall also be recorded along with DCRM test.

iii. Routine tests on Circuit breakers with Controlled switching device as per IEC/TR 62271-302.

16.5.1.11 DISCONNECTORS (ISOLATORS)

16.5.1.14.1 Disconnectors shall be three-pole group operated or Single-pole individual operated (as per single line diagram of the substation) and shall be installed in the switchgear to provide electrical isolation. The disconnectors shall conform to IEC-62271-102 and shall have the ratings as specified in BPS.

16.5.1.14.2 **CONSTRUCTION & DESIGN**.

16.5.1.14.2.1 The disconnectors shall be operated by electric motor suitable for use on DC system and shall be equipped with a manual operating mechanism for emergency use. The motor shallbe protected against over current and short circuit.

16.5.1.14.2.2 Disconnectors shall be suitable to switch the bus charging currents during their opening and closing and shall confirm to all three test duties viz TD1,TD2 and TD3 as per Annexure –F of IEC: 62271- 102.They shall also be able to make and break rated bus transfer current at rated bus transfer voltage which appears during transfer between bus bars in accordancewith Annexure –B of IEC: 62271-102. The contact shielding shall also be designed to prevent restrikes and high local stresses caused by transient recovery voltages when these currents are interrupted.

16.5.1.14.2.3 The disconnect switches shall be arranged in such a way that all the three phases operate simultaneously. All the parts of the operating mechanism shall be able to withstand starting torque of the motor mechanism without damage until the motor overload protection operates.

16.5.1.14.2.4 It shall be possible to operate the disconnect switches manually by cranks or hand wheels.

16.5.1.14.2.5 For motor-operated disconnect switches, the control should be electrically and/or mechanically uncoupled from the drive shaft when the switch is operated manually to prevent coincident power operation of the switch and the drive mechanism(s).

16.5.1.14.2.6 The operating mechanisms shall be complete with all necessary linkages, clamps, couplings, operating rods, support brackets and grounding devices. All the bearings shall be permanently lubricated or shall be of such a type that no lubrication or maintenance is required.

16.5.1.14.2.7 The opening and closing of the disconnectors shall be achieved by either local or remote control. The local operation shall be by means of a two-position control switch located inthe Local Control Cabinet (LCC).

16.5.1.14.2.8 Remote control of the disconnectors from the control room/SAS shall be made by means of remote/ local transfer switch.

16.5.1.14.2.9 The disconnector operations shall be inter-locked electrically with the associated circuit breakers in such a way that the disconnector control is inoperative if the circuit breaker is closed.

16.5.1.14.2.10 Each disconnector shall be supplied with auxiliary switch having additional 8 NO (Normally Open) and 8 NC (Normally Closed) contacts for future use over and above those required for switchgear interlocking and automation purposes. These spare NO and NC contacts shall be wired up to the local control cabinet.

16.5.1.14.2.11 The signaling of the closed position of the disconnector shall not take place unless it is certain that the movable contacts will reach a position in which the rated normal current,peak withstand current and short-time withstand current can be carried safely.

16.5.1.14.2.12 The signaling of the open position of the disconnector shall not take place unless the movable contacts have reached such a position that the clearance between the contacts is at least 80 percent of the rated isolating distance.

16.5.1.14.2.13 The disconnectors and safety grounding switches shall have mechanical/electrical inter- locks to prevent closing of the grounding switches when isolator switches are in the closed position and to prevent closing of the disconnectors when the grounding switch is in the closed position. Integrally mounted lock when provided shall be equipped with a unique key for such three phase group. Master key is not permitted.

16.5.1.14.2.14 The local control of the Isolator and high-speed grounding switches from the Local Control Cabinet (LCC) should be achieved from the individual control switches with theremote/local transfer switch set to local.

16.5.1.14.2.15 All electrical sequence interlocks will apply in both remote and local control modes.

16.5.1.14.2.16 Each disconnector shall have a clearly identifiable local, positively driven mechanical position indicator, together with position indicator on the local control cubicle (LCC) and provisions for taking the signals to the control room. The details of the inscriptions and colouring for the indicator are given as under :

	INSCRIPTION	COLOUR
Open position	OPEN	GREEN
Closed position	CLOSED	RED

16.5.1.14.2.17 All the disconnecting switches shall have arrangement allowing easy visual inspection of the travel of the switch contacts in both open and close positions, from the outside of the enclosure.

16.5.1.14.2.18 The disconnecting switches shall be provided with rating plates and shall be easily accessible.

16.5.1.14.2.19 The mechanical endurance class shall be M2 as per IEC for 400kV, 220 kV and 132kV disconnectors. **Electrical endurance class shall be E2.**

16.5.1.14.2.20 Mechanical position indication shall be provided locally at each disconnector and Electrical indication at each Local Control Cabinet (LCC) and SAS.

16.5.1.14.2.21 Manual operation facility shall be provide for each disconnector in the GIS.

16.5.1.14.2.22 The degree of protection for the Drive Mechanism box of disconnector shall be IP55.

16.5.1.14.2.23 Disconnect switch shall be capable of switching inductive currents as per IEC 60129 and bus transfer as per IEC 61128.

16.5.1.12 SAFETY GROUNDING SWITCHES

16.5.1.15.1 Safety grounding switches shall be three-pole group operated or single-pole individual operated (as per single line diagram of the substation). It shall be operated by DC electric motor and shall be equipped with a manual operating mechanism for emergency use. The motor shall be protected against over-current and short circuit.

16.5.1.15.2 Each safety grounding switch shall be electrically interlocked with its associated disconnectors and circuit breaker such that it can only be closed if both the circuit breaker and disconnectors are in open position. Safety grounding switch shall also be mechanically key interlocked with its associated disconnectors.

16.5.1.15.3 Each safety grounding switch shall have clearly identifiable local positive driven mechanical indicator together with position indicator on the Local Control Cabinet (LCC)and provision for taking the signal to Control room.

16.5.1.15.4 The details of the inscription and colouring for the indicator are given as under :

INSCRIPTION COLOUR

Open position	OPEN	GREEN
Closed position	CLOSED	RED

16.5.1.15.5 Interlocks shall be provided so that manual operation of the switches or insertion of the manual operating device will disable the electrical control circuits.

16.5.1.15.6 Each ground switch shall be fitted with auxiliary switches having 6 NO (Normally Open) and 6 NC (Normally Closed) contacts for use by others over and above those required for local interlocking and position indication purposes.

16.5.1.15.7 Provision shall be made for padlocking / suitable locking arrangement for the ground switches in either the open or closed position.

16.5.1.15.8 All portions of the grounding switch and operating mechanism required for grounding shall be connected together utilizing flexible copper conductors having a minimum cross- sectional area of 100 sq. mm.

16.5.1.15.9 The main grounding connections on each grounding switch shall be rated to carry the full short circuit current for 1 sec. and shall be equipped with a silver-plated terminal connector suitable for steel strap of adequate rating for connection to the grounding grid.

16.5.1.15.10 The safety grounding switches shall conform to the requirements of IEC-62271- 102 and shall have electrical endurance class: E2 & shall have mechanical endurance class M2 for 400 kV/220/132 kV voltage level..

16.5.1.15.11 The grounding switch shall be provided with test provision (insulated link) to permit test voltage up to 10 kV and up to 200 A to be applied to the main conductor without removing SF6 gas from the enclosure and without disassembling the enclosure except for ground shunt leads.

16.5.1.15.12 Combined Disconnectors & Safety grounding switch arrangement shall also be acceptable.

16.5.1.15.13 Mechanical position indication shall be provided locally at each switch and Electrical indication at each Local Control Cabinet (LCC) / SAS.

16.5.1.15.14 Manual operation facility shall be provided for the earth switches.

16.5.1.15.15 The degree of protection of the Drive Mechanism box of maintenance earth switch shall be IP55.

16.5.1.15.16 Termination point grounding switch shall be able to make short circuit current and capable of breaking the induced capacitive and inductive current as per IEC 61129 (Class-B duty) considering the transient recovery switching duty imposed on grounding switch.

16.5.1.13 HIGH SPEED MAKE PROOF GROUNDING SWITCHES:

Grounding switches located at the beginning of the line feeder bay modules shall be of the high speed, make proof type and will be used to discharge the respective charging currents, trapped charge in addition to their safety grounding function. These grounding switches shall be capable of interrupting the inductive and capacitive currents and to withstand the associated TRV. These shall confirm to class F and electrical endurance class E2 and mechanical endurance class M2.

16.5.1.16.1 High Speed Grounding switches shall be provided with individual/three pole operating mechanism suitable for operation from DC.

16.5.1.16.2 The switches shall be fitted with a stored energy closing system to provide fault making capacity.

16.5.1.16.3 The short circuit making current rating of each ground switch shall be at least equal to its peak withstand current rating as specified. The switches shall have inductive/

capacitive current switching capacity as per IEC-62271-102.

16.5.1.16.4 Each high speed make proof grounding switch shall have clearly identifiable local positive driven mechanical indicator together with position indicator on the Local Control Cabinet (LCC) and provision for taking the signal to Control Room/SAS.

16.5.1.16.5 The details of the inscription and colouring for the indicator shall be as under:-

	INSCRIPTION	COLOUR
Open position	OPEN	GREEN
Closed position	CLOSED	RED

16.5.1.16.6 High speed ground switch operation should be possible locally from Local Control Cabinet (LCC) as well as from SAS.

16.5.1.16.7 These high speed grounding switches shall be electrically interlocked with their associated circuit breakers and disconnectors so that the grounding switches cannot be closed if disconnectors are closed. Interlocks shall be provided so that the insertion of the manual operating devices will disable the electrical control circuits.

16.5.1.16.8 Each high speed ground switch shall be fitted with auxiliary switches having additional 6 NO (Normally Open) and6 NC (Normally Closed) contacts for use by others, over and above these required for local interlocking and position indication. All contacts shall be wired to terminal blocks in the Local Control Cabinet. Provision shall be made for padlocking the ground switches in their open or closed position.

16.5.1.16.9 All portion of the grounding switches and operating mechanism required for connection to ground shall be connected together utilizing copper conductor having minimum cross- sectional area of 120 sq. mm.

16.5.1.16.10 The main grounding connection on each grounding switch shall be rated to carry the peak withstand current rating of the switch for **3 sec. and shall be equipped with a silver-plated contacts and to be connected to copper flat riser outside the earthing switch module.**

16.5.1.16.11 The grounding switch shall be provided with test provision (insulated link) to permit test voltage up to 10 kV and up to 200 A to be applied to the main conductor without removing SF6 gas from the enclosure and without disassembling the enclosure except for ground shunt leads.

16.5.1.14 INSTRUMENT TRANSFORMERS

16.5.1.17.1 Current Transformers The current transformers and accessories shall conform to IEC: 61869 and other relevant standards except to the extent explicitly modified in the specification.

a) Ratios and Characteristics: The CT core distribution for various voltage levels shall be as per SLD. Further the numbers of cores, rating, ratios, accuracy class,etc. for the individual current transformers secondary cores shall also be as per the details mentioned in the scope. The knee point voltage of the CTs shall be minimum of 1:1 ratio of the rating of the CT cores. However, the exact requirement of knee point voltage shall be determined by CT sizing calculation which is to be provided during detailed engineering.

Where multi-ratio current transformers are required the various ratios shall be obtained by changing the effective number of turns on the secondary winding.

b) Rating and Diagram Plates: Rating and diagram plates shall be as specified in the IEC specification incorporating the year of manufacture. The rated current & extended current rating in case of current transformers and rated voltage, voltage factor & intermediate voltage in case of voltage transformers shall be clearly indicated on the name plate.

The diagram plates shall show the terminal markings and the relative physical arrangement of the current transformer cores with respect to the primary terminals (P1 & P2).

The position of each primary terminal in the current transformer SF6 gas section shall be clearly marked by two plates fixed to the enclosure at each end of the current transformer.

The Vk value of the CT used for distance protection shall have transient performance as per IEC 60044-6

C) Constructional Details:

i) The current transformers incorporated into the GIS will be used for protective relaying and metering purposes and shall be of metal- enclosed type.
ii) Each current transformer shall be equipped with a secondary terminal box with terminals for the secondary circuits, which are connected to the Local Control Cubicle. The star/ delta configuration and the inter connection to the line protection panels will be done at the CT terminal block located in the local control cubicle.
iii) Current transformers guaranteed burdens and accuracy class are to be intended as simultaneous for all cores.
iv) The rated extended currents for 800 kV and 420 kV class Current transformers shall beas given below:

Tap Ratio	**800kV, 3000A**	**400kV, 3000A**
	Rated extended currents in % of rated current	
500/1	**200**	**200**
1000/1	**---**	**---**
2000/1	**180**	**180**
3000/1	**120 (200 for 15 min)**	**120**

v) The secondary winding shall be rated for 2A continuously.
vi) For 245/145 kV class CTs, the rated extended primary current shall be 120% (or 150% if applicable) on all cores of the CTs as specified in the Section – Project.
vii) For 800/420/245/145 kV current transformer, characteristics shall be such as to provide satisfactory performance of burdens ranging from 25% to 100% of rated burden over a range of 5% to 120%(or specified rated extended current whichever is higher) of rated current in case of metering CTs and up to the accuracy limit factor/knee point voltage in case of relaying CTs.
viii) For 800kV CTs, the instrument security factor at all ratios shall be less than ten (10) for metering core. For 420/245/145kV 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.

ix) The wiring diagram, for the interconnections of the three single phase CTs shall be provided inside the Secondary terminal box.

x) The current transformers shall be suitable for high speed auto-reclosing.

xi) Provisions shall be made for primary injection testing either within CT or outside.

xii) All the current transformers shall have effective electromagnetic shields to protect against high frequency transients. Electromagnetic shields to be provided against high frequency transients typically 1-30 MHz.

16.5.1.17.2 VOLTAGE TRANSFORMERS

The voltage transformers shall conform to IEC- 61869 and other relevant standards exceptto the extent explicitly modified in the specification.

Voltage transformers shall be of the electromagnetic type with SF6 gas insulation. The earth end of the high voltage winding and the ends of the secondary winding shall be brought outin the terminal box.

a) **Ratios and Characteristics**: The rating, ratio, accuracy class, connection etc. for the voltage transformers shall be in accordance with Annexure 4 & Table 4A.

b)

Rating and diagram plates :Rating and diagram plate shall be provided complying with the requirements of the IEC specification incorporating the year of manufacture and including turns ratio, voltage ratio, burden, connection diagram etc.

Second`ary Terminals, Earthing

C) The beginning and end of each secondary winding shall be wired to suitable terminals accommodated in a terminal box mounted directly on the voltage transformer section of the SF6 switchgear.

All terminals shall be stamped or otherwise marked to correspond with the marking on the diagram plate. Provision shall be made for earthing of the secondary windings inside the terminal box.

The transformer shall be able to sustain full line to line voltage without saturation of transformer.

d) Constructional Details of Voltage Transformers :

i) The voltage transformers shall be located as a separate bay module and will be connected phase to ground and shall be used for protection, metering and synchronization.

ii) The voltage transformers shall be of inductive type, nonresistant and shall be contained in their own-SF6 compartment, separated from other parts of installation. The voltage transformers shall be effectively shielded against high frequency electromagnetic transients. The supplier shall ensure that there is no risk of Ferro resonance due to the capacitance of the GIS.

iii) The voltage transformers shall have three secondary windings.

iv) Voltage transformers secondary shall be protected by Miniature Circuit breakers (MCBs) with monitoring contacts for all the windings. The secondary terminals of the VT's shall be terminated to preferably RING type non-disconnecting terminal blocks in the secondary boxes via the MCBs.

v) The voltage transformer should be thermally and dielectrically safe when the secondary terminals are loaded with the guaranteed thermal burdens.

vi) The accuracy of 0.2 on secondary III should be maintained throughout the entire burden range up to 100 VA on all the three windings without any adjustments during operation. .

vii) The diagram for the interconnection of the VTs shall be provided inside secondaryterminal box.

viii) It should be ensured that access to secondary terminals is without any danger of accessto high voltage circuit.

ix) PT shall be provided with isolating link through external operation for the purpose of high voltage testing of GIS.

16.5.1.17.3 Tests:

i. In accordance with the requirements in Section-GTR, Current Transformer and Voltage Transformer should have been type tested and shall be subjected to routine tests in accordance with relevant IEC.

ii. The test reports of type tests, as applicable, as per IEC-61869-2 for CT, and IEC-61869-3 for IVT and following additional tests shall be submitted for the Employer's review. Thetype tests for which the procedure is under consideration as per above said IEC is not required to be considered.

a) Current Transformers (CT): Transmitted over voltage test for 145kV and above voltage rating

b) Inductive Voltage Transformers (IVT): Transmitted over voltage test for 145kVand above voltage rating

16.5.1.15 SURGE ARRESTORS

16.5.1.18.1 The surge arrestors shall confirm in general to latest IEC –60099-4.

16.5.1.18.2 **Insulation co-ordination and selection of surge arrestor**: The contractor shall be fully responsible for complete insulation co-ordination of switchyard including GIS. Contractor shall carry out detailed studies and design calculations to evolve the required parameters locations, energy capability etc. of surge arrestors such that adequate protective margin is available between peak impulse, surge and power frequency discharge voltages and BIL ofthe protected requirement. The locations of surge arrestors shown in single line diagram is indicative only. If the contractor feels that at some more locations the surge arrestors are required to be provided the same should also be deemed included in the offer.

16.5.1.18.3 The contractor shall perform all necessary studies and the report shall detail the limits of all equipment parameters which could affect the insulation co-ordination. The report shall also detail the characteristics of the surge arrestor and shall demonstrate that the selected arrestor's protective and withstand levels, discharge and coordinating currents and arrestor ratings and comply with the requirement of this specification.

16.5.1.18.4 The contractor shall also consider in the studies the open circuit breaker condition, fast transients generated by slow operation of disconnecting switches. The study report and design calculations shall be submitted for Owner's approval.

16.5.1.18.5 **Duty requirements of GIS Surge Arrestor**

16.5.1.18.7.7 The surge arrestor shall be SF6 gas insulated metal oxide and gapless type. The metal housing of the arrestor shall be connected to the metal enclosure of the GIS with flange, bolted and gasketed joint so that the arrestor housing is grounded through GIS enclosure.

16.5.1.18.7.8 Surge arrestor shall be disconnect-link type and be attached to the gas-insulated system in such a manner that they can be readily disconnected from the system while the system is being dielectrically tested.

16.5.1.18.7.9 The surge arrester shall be of heavy duty station class and gapless (Metal oxide) type without any series or shunt gaps.

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

16.5.1.18.7.11 Surge arresters for the 765 kV network shall be capable of discharging of severe re- energisation switching surges on a 765kV line with surge impedance of 270hms and capacitance of 13 nF/Km.

765 kV class arrester shall be capable of discharging energy equivalent to class 5 of IEC for a 765 kV system on two successive operation followed immediately by 50 HZ energisation with a sequential voltage profile as specified below:

1000 kVp for 3 peaks

910 kVp for 0.1 Sec.

885 kVp for 1 Sec.

866 kVp for 10 Secs.

16.5.1.18.7.12 Surge arresters for the 400 kV network shall be capable of discharging of severe re- energisation switching surges on a 400 kV, 450 Km long line with surge impedance of 300 ohms and capacitance of 12 nF/Km and over voltage factor of 2.3 p.u at the arrestor terminals.

400 kV class arrester shall be capable of discharging energy equivalent to class 4 of IEC for a 400 kV system on two successive operation followed immediately by 50 HZ energisation with a sequential voltage profile as specified below:

650 kVp for 3 peaks

575 kVp for 0.1 Sec.

550 kVp for 1 Sec.

475 kVp for 10 Secs.

16.5.1.18.7.13 245 & 145kV class arrester shall be capable of discharging energy equivalent to class 3 of IEC for 245 kV & 145 kV system respectively on two successive operations.

16.5.1.18.7.14 The reference current of the arresters shall be high enough to eliminate the influence of grading and stray capacitance on the measured reference voltage.

16.5.1.18.7.15 The surge arresters are being provided to protect the followings whose insulation levels are indicated in the table given below:-

Equipment to be protected	765kV system		400kV system		220KV system	132KV System
	Lightning impulse(kVp)	Switching surge (kVp)	Lightning impulse (kVp)	Switching surge (kVp)	Lightning impulse (kVp)	Lightning impulse (kVp)
Power Transformer	± 1950	± 1550	± 1300	± 1050	± 950	± 550
Instrument Transformer	± 2100	± 1550	± 1425	± 1050	± 1050	± 650
Reactor	± 1950	± 1550	± 1300	± 1050	-	-
CB/Isolator Phase to	± 2100	± 1550	±1425	± 1050	± 1050	± 650

ground						
CB/Isolator Across open contacts	± 1300 (-/+457)	± 1200 (-/+653)	± 1425 (-/+240)	± 900 (-/+345)	± 1200	± 750

16.5.1.18.6 **Constructional Features**

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

The arrestor enclosure shall be vertically or horizontally mounted to suit the layout of the switchgear as suggested by the supplier and each arrestor shall be fitted with a Online continuous resistive leakage current monitoring system. The system shall be provided with an interface to integrate with the substation automation system.

The main grounding connection from the surge arrestor to the earth shall be provided by the contractor. The size of the connecting conductor shall be such that all the energy is dissipated to the ground without getting overheated.

16.5.1.18.7 **Tests**

16.5.1.18.7.1 In accordance with the requirements stipulated, the surge arrestors shall conform to typetests and shall be subjected to routine and acceptance tests in accordance with IEC document.

16.5.1.18.7.2 Each metal oxide block shall be tested for the guaranteed specific energy capability in addition to the routine/acceptance test as per IEC-60099.

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

16.5.1.18.7.4 **Technical** Parameters: Technical parameters are as per Annexure 5.

16.5.1.16 OUTDOOR SF6/AIR BUSHINGS :

16.5.1.19.1 Outdoor bushings, for the connection of conventional external conductors to the SF6 metal enclosed switchgear, shall be provided where specified and shall conform to the requirements given in GTP.

16.5.1.19.2 The dimensional and clearance requirements for the metal enclosure will be the responsibility of the manufacturer and their dimensions must be coordinated with the switchgear.

16.5.1.19.3 Bushings shall generally be in accordance with the requirements of IEC -60137.

16.5.1.19.4 Insulation levels and Creepage distances: All bushings shall have an impulse and power frequency withstand level that is greater than or equal to the levels specified for GIS.

16.5.1.19.5 The creepage distance over the external surface of outdoor bushings shall not be less than 31mm/Kv.

16.5.1.19.6 Bushing types and fitting: The details of bushing shall be as follows:

- SF6 to air Bushing shall be of Polymer/composite type or better and shall be robust and designed for adequate cantilever strength to meet the requirement of seismic condition, substation layout. The electrical and mechanical characteristics of bushings shall be in accordance with IEC:60137. All details of the bushing shall be submitted for approval and design review.
- Polymer / composite insulator shall be seamless sheath of a silicone rubber compound. The housing & weather sheds should have silicon content of minimum 30% by weight. It should protect the bushing against environmental influences, external pollution and humidity. The hollow silicone composite insulators shall comply with the requirements of the IEC publications IEC 61462 and the relevant parts of IEC 62217. The design of the composite insulators shall be tested and verified according to IEC 61462.

16.5.1.19.7 **Mechanical forces on bushing terminals:** Outdoor bushings must be capable of withstanding cantilever forces due to weight of bus duct (GIB) on one side & AIS conductor/Al tube on the other side and short circuit forces.Type test reports as per applicable IEC including radio interference voltage (RIV) test shall be submitted in line with the requirement as specified in section GTR for approval.
The technical parameters of Bushing are as per GTP.

Corona rings shall be provided for SF6 to air bushing for 220kV and above voltage level.

16.5.1.17 GIS TO CABLE TERMINATION (IF APPLICABLE)

16.5.1.21.7 This scope covers the supply, erection, commissioning of connection assembly of extruded cables to gas-insulated metal enclosed switchgear (GIS) as per IEC 62271-209

16.5.1.21.8 The XLPE cables shall be connected to GIS by the interfacing of XLPE cable sealing end to GIS Cable termination enclosure.

16.5.1.21.9 The GIS to XLPE cable termination shall conform to IEC-62271-209.

16.5.1.21.10 The rating of XLPE cables for different voltages shall be as per BoQ.

16.5.1.21.11 The limits of supply of gas-insulated metal-enclosed switchgear and the cable termination shall be in accordance with IEC 62271-209.

16.5.1.21.12 Cable termination and cable connection enclosure shall be suitable for the requirements for which it is designed. This interface section shall be designed in a manner which will allow ease of operation and maintenance.

16.5.1.21.13 The SF6 cable end unit and connection support structure should be equipped with provisions for isolating and grounding of the cable sheath as per the requirement of cable sheath bonding system or pipe to permit cathodic protection of cable system (seeIEC62271-209)

16.5.1.21.14 The provision shall be made for a removable link. The gap created when the link is removed should have sufficient electric strength to withstand the switchgear high voltage site tests. The contractor may suggest alternative arrangements to meet these requirements. The corona rings/stress shields for the control of electrical field in the vicinity of the isolationgap shall be provided by the GIS manufacturer.

16.5.1.21.15 All supporting structures for the SF6 bus-duct connections between the XLPE cable sealing ends and the GIS shall be the scope of the contract. The supplier may specify alternative connecting & supporting arrangements for approval of the Employer.

16.5.1.21.16 The opening for access shall be provided in each phase terminal enclosures as necessary to permit removal of connectors to isolate the XLPE cables to allow carrying out the insulation tests. The general arrangement drawing of interconnecting bus-duct from GIS bay module to XLPE cable termination end shall also be submitted.

16.5.1.18 TRANSFORMER / REACTOR TERMINATION

16.5.1.21.1 **TRANSFORMER / REACTOR Direct Connection with GIS (if applicable)**

16.5.1.22.2.7 The scope covers the supply, erection and commissioning of connection assembly of Oil filled Transformer to gas-insulated metal enclosed switchgear (GIS) as per IEC 62271-211.

16.5.1.22.2.8 The limits of supply of gas-insulated metal-enclosed switchgear and the direct connection to oil filled transformer shall be in accordance with IEC 62271-211.

16.5.1.22.2.9 The transformer / reactor termination module enables a direct transition from the SF6 gas insulation to the bushing of an oil-insulated transformer / reactor. For this purpose, the transformer/reactor bushing must be oil-tight, gas-tight and pressure resistant. Any temperature related movement and irregular setting of the switchgear's or transformer's/reactor's foundations are absorbed by the expansion fitting.

16.5.1.22.2.10 Terminal connection arrangement to connect GIS duct to bushing and duct mounting arrangement details shall be submitted during detailed engineering for Employer's approval and for co-ordination with transformer and reactor supplier. Any modification suggested by transformer and reactor supplier shall have to be carried out by the GIS supplier to facilitate proper connection with the bushings of the transformer and reactors.

16.5.1.21.2 **TRANSFORMER / REACTOR CONNECTION WITH SF6/AIR BUSHING**

The oil filled transformers and reactors are as shown in the substation SLD. The oil to air bushings of the transformers and reactors shall be supplied by the respective Transformer/Reactor supplier and the same shall be connected to the SF6 ducts thru air to SF6 bushings to be provided under present scope.

In case of single phase Transformers/Reactors are being installed in the substation, HV&IV auxiliary bus for the Transformer/Reactor bank for connecting spare unit shall be formed inside the GIS hall as per the SLD furnished and as specified in Section project.

16.5.1.19 LOCAL CONTROL CUBICLE (LCC)

16.5.1.22.1 Functions

16.5.1.22.1.1 Each circuit-breaker bay shall be provided with a local control cubicle containing local control switches and a mimic diagram for the operation and semaphore/indicating lamp for status indication of the circuit-breaker and all associated isolators and earth switches together with selector switches to prevent local and remote and supervisory controls beingin operation simultaneously.

16.5.1.22.1.2 Status indications in the LCC shall be semaphore type or LED type.

16.5.1.22.1.3 Closing of the circuit- breaker from the local control unit shall only be available when the breaker is isolated for maintenance purposes. Circuit-breaker control position selector, operating control switch and electrical emergency trip push button shall be installed in the Local Control Cubicle. Circuit-breaker control from this position will be used under maintenance and emergency conditions only. The emergency trip push buttons shall be properly shrouded.

16.5.1.22.1.4 If Disconnector or earth switch is not in the fully open or closed position a "Control Circuit Faulty" alarm shall be initiated, and electrical operation shall be blocked.

16.5.1.22.1.5 20% spare terminals shall be provided in each LCC apart from terminals provided for the termination and interconnection of all cabling associated with remote and supervisory control, alarms, indications, protection and main power supply etc .

16.5.1.22.1.6 Where plugs and sockets connect control cabling between the local control cubicle and the switchgear these shall not be interchanged. In plug in connector type cable arrangement, min 2 cores of the cable with connected condition on both side up to the TB to be left unused as spare.

16.5.1.22.1.7 Hydraulic/pneumatic and SF6 auxiliary equipment necessary for the correct functioning of the circuit breaker, isolators and earth switches shall be located in a separate cubicle compartment.

16.5.1.22.1.8 LCC shall be suitable for remote operation from substation automation system (SAS). Each gas tight compartment shall be monitored individually per phase basis through SAS

16.5.1.22.2 Constructional Features

16.5.1.22.2.1 Local Control cubicle shall be free standing, floor mounting type (Standalone). Bay mounted LCCs are not accepted. It shall comprise structural frames completely enclosed with specially selected smooth finished, cold rolled sheet steel of thickness not less than 3 mm for weight bearing members of the panels such as base frame, front sheet and door frames, and 2.0mm for sides, door, top and bottom portions. There shall be sufficient reinforcement to provide level transportation and installation. Alternatively folded sheet panels of adequate thickness and strength is also acceptable. Minimum degree of protection of enclosure of LCC shall be IP55

16.5.1.22.2.2 Access to all compartments shall be provided by doors. All fastenings shall be integral with the panel or door and provision made for locking. Cubicles shall be well ventilated through vermin-proof louvers (if required) having anti insect screen. All doors shall be gasketed all around with suitably profiled Neoprene/EPDM gaskets conforming to the provision of IS 11149.

16.5.1.22.2.3 For LCC panel of each feeder bay (i.e. line, transformer, and reactor etc.), Bus Coupler bay and Bus Sectionalizer bay, separate AC/DC supply for power circuit of GIS switchgear shall be provided, fed directly from ACDB/DCDB. The control DC supply (for control, interlocking, signaling) shall be tapped from respective relay & protection panel. For LCC panel illumination and heating purpose Loop in Loop out AC Supply can be provided.

16.5.1.22.2.4 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/MCBs. 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 baseshall have imprints of the fuse 'rating' and 'voltage'.

16.5.1.22.2.5 Each LCC Panel shall be provided with the following

1. **Plug Point**: 240V, Single phase 50Hz, AC socket with switch suitable to accept 5/15 Amps pin round standard Indian plug, shall be provided in the interior of each cubicle with ON-OFF switch.
2. **Interior Lighting**: Each panel shall be provided with a door-operated LED lighting fixture rated for 240 Volts, single phase, 50 Hz supply for the interior illumination of the panel controlled by the respective panel door switch.
3. **Space Heater**: Each panel shall be provided with a thermostatically connected space heater rated for 240V, 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.

16.5.1.22.2.6 Operating mechanisms, auxiliary switches and associated relays, control switches, control cable terminations, and other ancillary equipment shall be accommodated in sheet steel vermin proof IP-65 cubicles.

16.5.1.22.2.7 The arrangement of equipment within cubicles shall be such that access for maintenance or removal of any item shall be possible with the minimum disturbance of associated apparatus. All the control switches shall be internal i.e. installed behind a lockable glass door, that allows a complete view of the annunciator and mimic diagram when the LCC door is closed. Necessary protection shall be provided to avoid inadvertent operation of control switches.

16.5.1.22.2.8 An interlocking scheme shall be provided that takes into account the following basic requirements.

- To safeguard maintenance personnel who may be working on one section of the equipment with other sections live.
- prevent incorrect switching sequences that could lead to a hazardous situation to plant, equipment and personnel.

16.5.1.22.2.9 Electrical bolt interlocks shall be energized only when the operating handle of the mechanism is brought to the working position. Visible indication shall be provided to show whether the mechanism is locked or free. Means, normally padlocked/handle lock, shall be provided whereby the bolt can be operated in the emergency of a failure of interlock supplies.

16.5.1.22.2.10 Where key interlocking is employed tripping of the circuit breaker shall not occur if any attempt is made to remove the trapped key from the mechanism. Any local emergency- tripping device shall be kept separate and distinct from the key interlocking.

16.5.1.22.2.11 Disconnecting switches shall be so interlocked that they cannot be operated unless the associated circuit-breaker is open except that where double bus bar arrangements are specified, on-load transfer of feeder circuits from one bus bar to another shall be made possible by interlocks which ensure that the associated bus coupler and its isolators are closed.

16.5.1.22.2.12 Bus coupler circuit breaker shall be interlocked so that it shall not be possible to open a bus coupler circuit breaker while on load change over on that side of the breaker is in progress.-

16.5.1.22.2.13 All isolating devices shall be interlocked with associated circuit-breakers and isolators in the same station so that it shall not be possible to make or break current on an isolating device unless a parallel circuit in that station is already closed.

16.5.1.22.2.14 Separate DC supply with changeover facility shall be provided in the LCC for control and power requirement of the GIS bay components and local alarm/indication.

16.5.1.20 CABLING BETWEEN LCC PANEL AND GIS EQUIPMENT

16.5.1.23.1 The armoured screen cable shall be of 1.1kV grade, multicore, annealed copper conductor, Tinned copper braided screen (approx.85%coverage). This cable shall be shielded upto 10MHzand earthed at both ends through double compression gland.

16.5.1.23.1 The core insulation and outer sheath of cable shall be of halogen-free special polymer.

16.5.1.23.2 The cable shall be flame-retardant, flexible, abrasion-and wear-resistant.

16.5.1.23.3 The size of core shall not be less than 2.5 sq. mm for instrument transformers and 1.5 sq. mm for other control cable.

16.5.1.23.4 Prefabricated cables with heavy duty multi-point plug-in connections on GIS end shall be provided.

16.5.1.23.5 All instrument transformer connections shall be hard wired to terminal block via ring type connection.

16.5.1.21 GIS BUILDING

16.5.1.24.1 The buildings shall house each voltage class Gas Insulated Switchgear (GIS) and other associated equipment inside each of the GIS buildings. GIS building(s) shall be constructed for the specified number of bays/diameters as per project requirement including space for future bays.

16.5.1.24.2 For finalizing the dimensions of GIS building the requirement of Turning radius to rotate the largest removable component for assembly/disassembly shall be taken in to consideration along with the gas cart movement & high voltage test bushing etc. around the GIS module.

16.5.1.24.3 Wherever GIS Building of already exists, then the existing GIS Building(s) for respective voltage class shall be suitably extended keeping the width of the building same to accommodate the number of bays/diameters as specified in the Project.

16.5.1.24.4 The contractor shall submit the design & construction proposal of the building along with necessary information, data, and drawings during the detailed engineering according to the complete requirements.

16.5.1.24.5 The area for GIS Building(s) is indicated in the tender document. The area given is for reference only and may vary according to the requirement of the equipment to be installed inside. The contractor shall finalize the dimensions according to the equipment offered by them providing enough space & access for erection, operation and maintenance.

16.5.1.24.6 The contractor shall place their panels i.e. Bay level units, bay mimic, relay and protection panels, RTCC panels, Communication panels etc. in a separate Relay Panel Room in the GIS building. The size of the room shall be such that all the panels for the bays/ diameters shall be accommodated in the above room. The panel room shall be air-conditioned. Further, the temperature of the room shall be monitored through substation automation system by providing necessary temperature transducers.

16.5.1.24.7 For cable termination type GIS design, cable cellar room shall be considered as a part of GIS building.

16.5.1.22 ELECTRIC OVERHEAD CRANE:

16.5.1.25.1 One EOT Crane each for GIS hall of suitable capacity shall be provided for erection & maintenance of largest GIS component/assembly. The crane shall consist of all special requirements for erection & maintenance of GIS equipment. The capacity of the crane shall be sized to lift the heaviest GIS switchgear component crane.

16.5.1.25.2 The Crane shall be used for the erection and maintenance of the GIS switchgear component and all plant installed in the GIS switchgear room. On completion of erection of the switchgear, the Contractor shall completely service the crane before the Taking Over Certificate is issued. Crane hook approaches shall be of the minimum possible dimensions to ensure maximum coverage of the plant area.

16.5.1.25.3 The crane(s) shall be capable of lifting and accurately positioning all loads ranging from full crane rated capacity to at least 10% rated capacity.

16.5.1.25.4 The crane shall have minimum speeds under full load of:

i. Hoisting Speed 2 meters/minute
ii. Cross Travel 16 meters/minute Long Travel 20 meters/minute
iii. Creep speed shall be of25% of operating speed

16.5.1.25.5 The electric overhead cranes shall be provided with walkways, platforms. LT platforms shall be provided on non DSL side. Guard hand rails shall be provided along the bridge rails and on the crab of EOT crane to facilitate cleaning/maintenance of the crane and to give access to the GIS room high bay lighting and ventilation duct and grilles. The platform and walkways shall be designed to support any weight to be imposed upon them during crane overhaul. An access platform shall be provided together with a guarded ladder on the crane to allow access to the bridge rails.

16.5.1.25.6 The crane shall be possible to be operated through the cable, through the pendant control and which shall be easily accessible from the floor of GIS building and through remote control device. Manufacturer/contractor shall submit the capacity calculation of crane for GIS hall considering a factor of safety of 5.

16.5.1.25.7 The crane for 132kV GIS shall have minimum height of 8.0 meters & 220kV GIS shall have minimum height of crane of 9.0 meters and for 400kV GIS it shall have minimum height of 10.5 meters or as per actual requirement whichever is higher. In case the GIS hall is to be extended, the scope of work also involves extension of EOT crane girders to facilitate movement of EOT crane in the extended portion of GIS hall.

16.5.1.25.8 The following tests should be performed for EOT Crane:

16.5.1.25.9 The crane shall be tested at manufacturer work under full load and 25 percent overload of hoisting and cross transverse motions as a routine test.

16.5.1.25.10 Further the following tests may be done at site after installation of the crane at site a. Check althea accessories for proper function.

16.5.1.25.11 The following tests may be EOT Crane:- The following tests may be EOT Crane:-

a. The crane shall be tested at manufacturer work under full load and 25 percent overload of hoisting and cross transverse motions as a routine test.

b. Further the following tests may be done at site after installation of the crane at site

i. Check all the accessories for proper function
ii. No load test
iii. Load test as per site conditions. (with 25% overload)

16.5.1.25.12 Constructional Details

16.5.1.25.12.1 The double web, box construction crane bridge girders shall be in one piece or in pieces suitable for transportation. If the design is of multi piece construction, it shall require the approval of the Engineer in Charge. Cross travel rails shall be fixed to the bridge girders by clamping only and not welding. Plates, bars, angle sections and where practicable other rolled sections, used in the load bearing

members of structures shall be not less than 8 mm thickness. The end Carriages shall be of double web plate box construction or I section connected to the girders by welding at top or by large gusset plates and fitted bolts to ensure maximum rigidity. Drop stops and jacking pads shall be built-in features. Full length plate form of checker plate of minimum thickness 8 mm shall be provided along both sides of the crane to ensure easy, safe excess to the crane crab, travel gears and other parts. Safety railing shall be provided on crane bridges and crab frame. Foot-walk shall have sufficient width to give 500 mm minimum clear passage at all points, EOT Crane shall be single girder (upto 5T for132kVVoltage level) and double girder (above 5T for 220kV and above voltage level).Voltage level) and
double girder (above 5T for 220kV and above voltage level).

16.5.1.25.12.2 EOT Crane shall be double girder.

16.5.1.25.12.3 Rope Drums

Rope drums shall be of cast steel or fabricated from seamless tubes, conforming to the relevant Indian Standards. Fabricated rope drums shall be stress relieved before any machining takes place. The sizing of drum shall conform to IS 3177 Clause 5.

16.5.1.25.12.4 Rope Sheaves

Rope sheaves shall be of cast steel or fabricated from rolled steel plates, conforming to Clause 6 of IS 3177.

16.5.1.25.12.5 The wires shall **be steel cored** for all cranes. Ropes shall be of regular right hand lay as per IS 2266. The rope construction shall be 6 x 37 up to 16 mm diameter and 6 x 36 above 16 mm diameter, with a factor of safety specified as per Clause 5.6.1 of IS 3177. **Wire rope calculation shall be carried out by considering N-1 falls (number of ropes) to take care of 125% load.**

16.5.1.25.12.6 Hook Block

The sheaves shall be fully encased in close fitting guards fabricated from steel plate. Smooth opening shall be provided in the guards to allow for free movement of the rope. Holes shall be provided for oil drainage.

16.5.1.25.12.7 Lifting Hooks

The lifting hook shall be one that will best suit this type of crane and as per IS 3177. Hooks shall be type tested by a third-party agency such asSGS or Lloyds..

16.5.1.25.12.8 Gears and Gear Boxes

Straight and helical spur gearing shall be used for all motions. All first reduction gears shall have helical teeth. All pinions shall be integral with the shaft. All gears shall be hardened and shall be of tempered alloy steel having metric module. Overhung gears shall not be used. The design and general arrangement of gear boxes shall be as per Clause 10 of IS 3177. All gearing shall be totally enclosed/immersed in oil.

16.5.1.25.12.9 Track Wheels

Crab/Crane wheels shall be double flanged. Wheels shall be mounted in anti-friction roller bearings housed in “L” shaped bearing brackets for ease of removal during routine maintenance. Solid wheels shall be of forged/rolled steel or cast steel. In general, the track wheels shall conform to Clause 11 of IS 3177.

16.5.1.25.12.10 Rails

The rails shall be specified as being suitable for the crane duty used; no square bars will be acceptable. The rails shall be complete with end stops, holding down bolts and taper washers and shall be suitable for connection to the station earth. Access to the crane for maintenance purposes from the walking plate form by means of a steel ladder with cage shall be provided at **non-DSL** end. The crane shall be provided with full length walkway on drive side girder and small walkway on another girder.

Walkway shall be at least 500 mm clear inside. **The rails shall be copper headed steel of type tested design.**

DSL bus bar shall be PVC shrouded copper bus bar. Buffer/Stopper shall be designed with steel with spring & rubber cushioning suitably placed to take the impact of the crane.

16.5.1.25.12.11 Couplings

All couplings shall be of steel or cast iron of grade 260 conforming to IS 210 and shall be designed to suit the maximum torque that may be developed. The manual drive shaft and hoist drum shall be connected to the gear box input shaft through a flexible shock absorbing coupling as per Clause 8 of IS 3177.

16.5.1.25.12.12 Bearing and Bearing Housing

Anti-friction bearing housings shall be used throughout, except where required otherwise for technical reasons, conforming to Clause 7 of IS 3177.

16.5.1.25.12.13 Shafts

All shafts shall be made of steel as per Clause 9 of IS 3177.

16.5.1.25.12.14 Electrical details

The general technical details for the electrical systems specified elsewhere in the document will apply to the electrical equipment for the gantry crane also. The following points deal with the special requirements for the crane. In case of any contradiction with the electrical specifications described elsewhere in this document, the special requirements detailed hereafter shall govern.

415 V, 3 Phase, 4 wire electric power supply will be available at one point for the crane bus. The Tenderer shall provide a metal enclosed switch box housing a 250 A MCCB TPN switch, CT operated ammeter and voltmeter, with selector switch. This switch box shall be located approx. 1.2 meters above the floor level. The incoming cable must be of suitable size copper conductor, PVC insulated, PVC sheathed, strip armoured. From this switch onwards, the Tenderer shall arrange and terminate the supply at the crane bus.

16.5.1.25.12.15 Crane Power Supply

415 Volts +/- 10%, 3 Phase, 4 Wire, 50 Hz +/- 5%, AC through trolley lines. Current Collector

Two No. per trolley line shall be provided; each rated for 100% of total crane rating. Double collectors on each earth trolley shall be provided and these shall be different from those on the power trolley line. Collector rollers and shoes shall be designed to reduce sparking to the minimum level possible Power Distribution on Crane. An off/load manual isolator, with a locking facility shall be provided immediately after the current collectors on the incoming line on the crane.

Power from the isolator shall be taken to the circuit breaker located in protective panel of the crane. The breaker shall be provided with under voltage, overload and short circuit release or relays. The breaker can only be closed when:

All controllers are in neutral position;

None of the stator or directional contactors are in closed position; Door/gate switches are not actuated;

Rotary and gravity limit switches for hoist motion not operated.

16.5.1.25.12.16 Power Supply for Lighting and Magnet Circuits

Power for lighting and magnet circuits shall be tapped from the incoming side of isolator near current collectors.

16.5.1.25.12.17 Power Supply for Cross traverse Motion

A flexible traveling crane system mounted on a retracting support system shall be used. The conductor shall consist of insulated multi-conductor or several single conductor cables with permanent termination on the bridge and on the trolley. The flexible trailing cables shall have ample length and shall be supported by means of properly designed movable clamps. The clamps shall be fitted with rollers and shall run freely on a guide rail allowing relative movement of bridge and trolley without undue stress or wear on the suspended cables. The flexible copper cables shall be of butyl rubber or EPR insulated CSP sheathed type 650/1100 V Grade.

16.5.1.25.12.18 Panels

All panels shall be of free-standing floor mounted construction, suitable to withstand any vibrations emanating from the crane. The panel and its components shall conform to standards of Electrical Technical Specifications for LT Switchgear/Panel, described elsewhere in this document.

16.5.1.25.12.19 Motors

Heavy duty motors suitable for crane operation, shall be reversible, suitable for frequent acceleration and mechanical breaking, totally enclosed, fan cooled, SCIM type. The duty of the motor shall be S5, as per IS 325. Class of insulation shall be “F” with temperature limited to class B. The pull-out torque is to be not less than 225% of full load torque, corresponding to 40% CDF (Cycle Duration Factor of the motor). The main motor shall have the speed ranges suitable for gearbox and operating speed for a Class 2 crane.

16.5.1.25.12.20 Brakes shall be provided for hoisting motions. Brakes shall be thruster type. DCEM brakes in combination can also be used. No converted DC shall be used in crane. Brakes shall be designed to be fail-safe whenever there is a current interruption, either intentionally or by main power supply failure. The capacity of brakes, brake drums, shoes and brake adjustment shall be as per Clause 14.4 of IS 3177.

16.5.1.25.12.21 Limit Switches

Only drum limit switches are acceptable. Roller operated, resetting limit switches shall be provided for all motors. For each hoist motion, a rotary type over-winding self-resetting limit switch shall be provided. An indication shall be provided to the operator whenever this limit switch has been operated. Limit switches shall be fitted to prevent over travelling and over traversing and any other special requirements.

16.5.1.25.12.22 Resistance

Resistances shall be air-cooled, robust, heavy duty, corrosion resistant, punched stainless **steel grid type** resistor. Suitable tapping points shall be provided. Resistance boxes shall be mounted in racks that permit independent travel of any selected box.

16.5.1.25.12.23 Pendent Controller Pendent push button station shall comprise of the following and be suitable for 110 V AC:

1. Key operated ON push button-standard green button on signal lamp-green lens.
2. Emergency OFF push button-standard red button.
3. Hoisting push button- standard black button.
4. Lowering push button-standard yellow button.
5. Cross traverse forward push button- standard black button.
6. Cross traverse reverse push button- standard black button.
7. Long traverse forward push button- standard black button.
8. Long traverse reverse push button- standard black button.
9. Crane light ON/OFF push button.
10. Bell ON/OFF push button
11. Radio control system interlocked with the pendant push button station to prevent any mal-operation.
12. All other standard push buttons shall be provided. Push button station shall be suitably earthed through flexible cable. Indication lamp for functioning error shall be provided.

16.6 SEISMIC DESIGN CRITERIA:

The equipment shall be designed for operation in seismic zone V for earthquake resistance. The seismic loads are due to the horizontal and vertical acceleration which may be assumed to act on concurrently. Seismic Qualification requirements shall be as per IEC 62271-207 for the design of equipment. The equipment along with its parts shall be strong enough and sufficiently well connected to resist total operating stresses resulting from the forces in normal operation, but in case of abnormal condition shall also resist with forces superimposed due to earthquakes. Test Report/Analysis Report should be furnished.

16.7 DESIGN REVIEW

16.7.1 Design reviews shall be conducted by Employer; however the entire responsibility of design shall be with the supplier.

16.7.2 Employer may also visit to the supplier’s works to inspect design, manufacturing and test facilities.

16.7.3 The design review will commence after placement of award with the successful contractor and shall be finalized before commencement of manufacturing activity. These design reviews shall be carried out in detail to the specific design with reference of the GIS under the scope of this specification. Employer reserve the right to waive off the design review during detailed engineering.

16.7.4 The design review shall be conducted generally following the, “User Guide for the application of Gas Insulator Switchgear (GIS) rated voltage of 72.5kV and above" – CIGRE report No. 125 prepared by CIGRE Working Group 23.10.

16.7.5 The manufacturer will be required to demonstrate the use of adequate safety margins for thermal, mechanical, dielectric, insulation coordination and vibration etc. design to take into the account the uncertainties of his design and manufacturing processes.

16.7.6 The scope of such a design review shall at least include the following:

The scope of such a design review shall at least include the following:	
1.	Dielectric Stress of Solid Insulation like Gas Barrier, support insulator etc.
2.	Dielectric stress of SF6 Gas Volume.
3.	Mechanical strength of enclosure, expansion joints etc.
4.	Criteria for providing expansion joint.
5.	Sealing system
6.	Insulation coordination
7.	Thermal stress and resulting increase in gas pressure during short circuit condition.
8.	Earthing of enclosure w.r.t circulating current.
9.	Seismic design, as per IEC 62271-207
10.	Circuit Breaker.
11.	Isolator and Earth switch.
12.	Voltage transformer.
13.	Current Transformer.
14.	Surge Arrester.
15.	Bushing.
16.	***Bus duct***
17.	Co rrosion protection.
18.	Ele ctrical and physical Interfaces with substation.
19.	Te sting capabilities.
20.	In spection and test plan.
21.	Transport and storage.
22.	Maintainability.
23.	Site Test.
24.	***Proper Interfacing of High voltage test bushing.***
25.	***TEV calculation for proper designing of insulators and bushings.***
26.	***Ferro Resonance test report for GIS VT***
27.	***Calculation of thermal expansion due to temperature rise in GIS.***

16.7.7 Further, the manufacturer shall furnish the following information during detailed engineering:

a) Study report of VFTO generated for GIS installation for 400 kV and above.

b) Calculation for adequacy of UHF sensors to be provided in GIS Installation

c) The calculations and documents in support of the average intensity ofelectromagnetic field on the surface of the enclosure.

d) Calculations to show that there is no Ferro resonance due to capacitance of GIS forthe voltage transformers.

e) Calculations in support of touch & step voltages in all enclosures and earthing ofcomplete GIS installation.

f) Measures to mitigate transient enclosure voltage by high frequency currents.

g) The acceptance criteria and limits of impact (of impact recorder) in all three directions which can be withstood by the equipment during transportation and handling.

16.8 TYPE TESTS

The offered GIS equipment shall conform to the type tests as per IEC-62271-203.Contractor shall submit type test reports for the following type tests & additional type tests.

Sl.	Description of the Type Test for GIS
1	Tests to verify the insulation level of the equipment and dielectric test on auxiliary circuits
2	Tests to prove the temperature rise of any part of the equipment and measurement of the resistance of the main circuit
3	Tests to prove the ability of the main and earthing circuits to carry the rated peak and rated short time withstand current
4	Tests to verify the making and breaking capacity of the included switching Devices
5	Tests to prove the satisfactory operation of the included switching devices
6	Tests to prove the strength of the enclosures
7	Gas tightness tests
8	Tests on partitions
9	Tests to prove the satisfactory operation at limit temperatures
10	Tests to assess the effects of arcing due to internal fault
11	Verification of the degree of protection of the enclosure
12	Tests to prove performance under thermal cycling and gas tightness tests on Insulators
13	Additional tests on auxiliary and control circuits
14	Reactor current switching test For Reactive Current switching capability as per Clause 6.4.1
15	Test to demonstrate the Power frequency withstand capability of breaker in open condition at lock out pressure.
16	Electromagnetic compatibility tests (if applicable)
17	Radio inference voltage tests
18	Test report for 10Kv Insulation earth switch,
19	Test report of operating mechanisms for all the duties.

The test reports of the above type tests for GIS (including type test report on Circuit breaker, Disconnect Switch, Grounding switches, Current and Voltage transformers as per relevant IEC and type tests of SF6/Air & Oil bushing as per IEC 60137 shall be submitted for approval as per Section- GTR, Technical Specification.

16.9 MISCELLANEOUS

16.9.1 **Painting of enclosure**: All enclosures shall be painted externally as per manufacturer'spainting procedure.

16.9.2 **Heaters:** Wherever required, heaters shall be provided to prevent moisture condensationinside various Marshaling boxes.

16.9.3 Identification & Rating plate

Each bay shall have a nameplate showing

a) Each module will have its own Identification & rating plate. The rating plate marking for each individual equipment like Circuit breaker, Disconnect Switch Grounding switches, Current transformer, Voltage transformers, Surge arrester etc shall be as per their relevant IEC.

b) A schematic diagram indicating their relative locations.

c) Overall rating plate giving all relevant parameters of GIS

16.10 TRANSPORT OF EQUIPMENT TO SITE.

The contractor shall be responsible for the loading, transport, handling and offloading of all equipment and materials from the place of manufacture or supply to site. The contractor shall be responsible to select and verify the route, mode of transportation and make all necessary arrangement with the appropriate authorities as well as determining any transport restrictions and regulations imposed by the government and other local authorities. All transport packages containing critical units viz Circuit breakers and Voltage transformers shall be provided with sufficient number of impact recorders (on returnable basis) during transportation to measure the magnitude and duration of the impact in all three directions. In case of electronic impact recorder, the recording shall commence in the factory and must continue till the units reach site. The data of electronic impact recorders shall be downloaded at site and a soft copy of it shall be handed over to Engineer – in –charge. Further, contractor shall communicate the interpretation of the data within three weeks.

16.11 PACKING, STORAGE AND UNPACKING

16.11.1 All the equipment shall be carefully packed for transport by sea, rail and road in such a manner that it is protected against the climatic conditions and the variations in such conditions that will be encountered enroute from the manufacturer's works to the site.

16.11.2 The SF6 metal clad equipment shall be shipped in the largest factory assembled units that the transport and loading limitations and handling facilities on site will allow to reduce the erection and installation work on site to a minimum.

16.11.3 Where possible all items of equipment or factory assembled units shall be boxed in substantial crates or containers to facilitate handling in a safe and secure manner. Shouldthe units be considered too large for packing in crates, they shall be suitably lagged and protected to prevent damage to any part, particularly small projections, during transport and handling. Special lugs or protective supports shall be provided for lifting to prevent slings and other lifting equipment from causing damage. Each crate, container or shipping unit shall be marked clearly on the outside to show where the weight is bearing and the correct position for the slings.

16.11.4 Each individual piece to be shipped, whether crate, container or large unit, shall be marked with a notation of the part or parts contained therein.

16.11.5 Special precautions shall be taken to protect any parts containing electrical insulation against the ingress of moisture. This applies particularly to the metal clad equipment of which each gas section shall be sealed and pressurized prior to shipping. Either dry nitrogen/air or dry SF6 gas shall be used and the pressure shall be such as to ensure that, allowing for reasonable leakage, it will always be greater than the atmospheric pressure for all variations in ambient temperature and the atmospheric pressure encountered during shipment to site and calculating the pressure to which the sections shall be filled to ensure positive pressure at all times during shipment.

16.11.6 Blanking plates, caps, seals, etc., necessary for sealing the gas sections during shipment to site which may on later stage necessarily be used during repair and maintenance shall remain the property of AEGCL. Balance blanking plates, caps, seals, etc shall be returnable to the contractor. If considered necessary, blanking plates or other sealing devices shall be provided with facilities for measuring the gas pressure and recharging at any time during the transport period. Any seals, gaskets, 'O' rings, etc. that may be used as part of the arrangement for sealing off gas sections for shipment of site, shall not be used in the final installation of the equipment at site. Identification numbers shall be stamped into the blanking plates, etc., and on the switchgear equipment to which they are fitted so that they can easily be identified and refitted should it ever be necessary to ship sections of the switchgear back to the manufacturer's works for repair.

16.11.7 Valves and other gas couplings associated with the switchgear gas systems shall be adequately protected against damage from any bumps or physical blows. They shall also be capped to prevent ingress of dirt or moisture or damage to any coupling, pipes, threads or special fittings. Any explosion vents and other pressure relief devices, shall be suitably sealed and protected to prevent accidental exposure of the sealed sections during shipmentto site.

16.11.8 For bus ducts involving male and female joints of the current carrying conductor, the same shall be transported in disassembled condition to avoid any damage during transit. All bright parts liable to rust shall receive a coat of anti-rusting composition and shall be suitably protected.

16.11.9 The contractor shall ensure that during the period between arrival at site and erection, all materials and parts of the contract works are suitably stored in such approved manner as to prevent damage by weather, corrosion, insects, vermin or fungal growth. The scope of providing the necessary protection, storing on raised platform, as required etc. is included in the works to be performed by the contractor. **Cost of the raised platform for temporary storage is deemed to be included in overall cost.** The raised platform needs to be made ready before arrival of GIS equipment at site. The contractor may use the available storage areas at site with permission of site in charge. performed by the contractor. Cost of the raised platform for temporary storage is deemed to be included in overall cost. The raised platform needs to be made ready before arrival of GIS equipment at site. The contractor may use the available storage areas at site with permission of site in charge. **The GIS components shall be stored in a single layer such that all the components can be easily accessible.**

16.11.10 The equipment shall be unpacked immediately before Installation. They shall not be left lying unnecessarily in open crates or containers. Special precautions shall be taken when gas sections which have been sealed and pressurized for shipping are opened up to reduce the ingress of dirt and atmospheric moisture to a minimum. Whenever possible this shall only be done immediately prior to installation and if any section is to be left outside for any length of time after being opened, it shall be resealed and pressurized with either dry nitrogen or SF6 gas until required.

16.11.11 For the purpose of release of payment linked to receipt and physical verification in case of GIS equipment it shall mean random opening and physical verification of one number of packing unit of each type of main equipment (i.e. GIS CB/ISO/ES/PT/LA/**SF6 to air bushing & cable termination module etc.)** for each voltage level. Thereafter proper re-packing of the GIS unit shall be ensured as per manufacturer recommendation.

16.12 INSTALLATION OF GIS

16.12.1 Civil works of GIS Hall shall be completed in all respects before taking up the installation and it shall be ensured that Ventilation System is operational and all dust and dirt in the hall are removed. **No dust shall enter the GIS hall after complete installation of the GIS modules. The GIS Hall needs to be maintained with positive pressure of +5mm water column before starting installation of GIS modules.**

16.12.2 The installation area shall be secured against entry of unauthorized personnel. Only certified manufacturer's engineer and supervisor shall undertake the erection works. Engineers and supervisors of the manufacturer shall submit authorization and competency certificate to AEGCL.

16.12.3 Un-packaging of GIS modules shall be done outside the GIS hall and in no case module tobe taken inside GIS hall with packing.

16.12.4 **All assembly work shall be done by qualified personnel only who are to be identified and list submitted to AEGCL site before starting of erection work.**

16.12.5 Assembly drawing for GIS erection for the section under progress shall be available and displayed in GIS hall at the time of erection work.

16.12.6 Working personnel shall clean their shoes or apply covers on shoes before entering the immediate working area. The working clothes of authorized personnel shall be made of non- fluffy material.

16.12.7 **All man entry door in GIS hall shall be of double door type and shall have automatic close facility after entry of personnel to avoid dust and moisture entry**. Walls and ceiling shall be in a condition so that neither dirt nor plaster might fall or rub off and formation of condensation water in ceiling shall be prevented under any circumstances.

16.12.8 Floor in the installation area shall have a firm surface and shall be kept dust free with a vacuum cleaner. Vacuum cleaning to be done on regular basis. **GIS hall floor shall be anti-skid type and shall not damage due to movement of gas cart.**

16.12.9 Only T&P and consumables required for GIS erection shall be kept in GIS during erection.

16.12.10 In case of outdoor installation of GIS or of GIS components open gas compartments shall be protected from dust and moisture ingress (by tarpaulin covers/protective enclosure/chamber etc)

16.12.11 Bus duct exits in the GIS hall's wall shall be kept covered by suitable means until permanent cover is provided after installation of bus ducts.

16.12.12 Maintenance room (as a part of LCR room) shall be constructed for carrying out repair works/ small part assembly. All excess material (not required for immediate installation works) test equipment and tools and tackles to be stored separately from GIS hall in thisroom for rework.

16.12.13 Erection agency shall submit method statement and make available formats for checking during each stage of hall preparation, assembly process and final checks to be approved by AEGCL site before start of erection. Shock recorder down loaded data and analysis shall be submitted preferably before commencement of erection work. In case of violationof shock limits, expert form manufacturer shall visit and do the joint internal inspection and shall submit analysis report before giving clearance for erection. If required the module shall be taken back to factory for further analysis and testing.

16.12.14 Cleaning is of utmost importance and hence before assembly, all the loose metal parts, subassemblies and all contact & sealing surfaces shall be cleaned before installation. Cleaning shall be carried out with specified cleaning agents of the manufacturer, in no condition water is to be used except for external surfaces. Further, prior to opening of gas compartment, the same shall be thoroughly cleaned externally. The vacuum cleaning of the installation area shall also be done specially the immediate vicinity of the flanges to be connected.

16.12.15 All Civil Work inside building including internal cable trench shall be completed beforeGIS installation.

16.12.16 Installation of flanges shall be done immediately after removal of transport covers. Transport covers, O-rings and other packing material of GIS shall be taken out immediately after removal.

16.12.17 O Rings shall be properly stored and taken out only before installation. O Rings are also tobe cleaned before use with manufacturer authorized cleaning agent.

16.12.18 At all points of time during installation authorized personnel shall use suitable gloves to avoid contamination.

16.12.19 Cable termination work shall commence only after completion of GIS equipment erection, as during GIS installation period laying and termination of cables interferes with the GIS erection work and affects cleanliness.

16.12.20 Approved Field Quality Plan shall be followed during site work.

16.13 ON SITE TESTING

After the GIS Switchgear has been fully installed at site and SF6 gas filled at rated filling density, the complete assembly shall be subjected to the site tests as per IEC-62271-203 Method statement/ procedure of ON SITE high voltage testing, PD measurement and Switching Impulse test shall be submitted by contractor in advance.

(A) Commissioning Tests/On Site Tests After Erection:

After erection, and before putting into service, the gas-insulated metal enclosed Switchgear shall be tested for the correct operation and dielectric strength of the equipment.

These tests and verifications shall comprise:

(1) Tests to be conducted on the circuit breaker at site at all required operating sequences Measurement of operating time, Checking of wiring and connections and dielectric checks Indications, alarms and interlocks, auxiliary contacts Operation at minimum and maximum control supply voltage/pressure Operation of anti-pumping device.

(2) Test to be conducted on the Disconnectors at site Checking of wiring and connections and dielectri checks Indications, alarms and interlocks, auxiliary contacts Operation at minimum and maximum control supply voltage/pressure

(3) Other Tests at Site: Dielectric tests on auxiliary circuits, Measurement of the resistance of the main circuit Measurement of gas condition, Gas tightness tests General verifications Tests as per IEEE C37.122.1 clause 4.10.5 Demonstration of operationalcompatibility with SCADA Mechanical operation tests of circuit breakers Disconnectors and earthing switches and high-speed earthing switches Insulation resistance measurement. Calibration of all the measuring equipment shall be checked before energization of the GIS.

(B) Power Frequency Test: On Site Testing of GIS Power frequency tests for the completed GIS at site shall be complied as per IEC 60270. Power frequency tests for the completed GIS at site shall be possible without removing the voltage transformers. The power frequency test voltage at site shall be 80% of the factory test voltage for 1 min at 100Hz.The Supplier is responsible to furnish the test equipment for conducting following performance tests at site. Voltage tests on main circuits at reduced voltage (80% p.f.) comprising:

50 Hz A.C. voltage test for 1 min

Partial Discharge test

The manufacturer shall provide:

-The test voltage source.

-All connections between the switchgear and the test voltage source.

The procedure to be implemented following a discharge during dielectric tests is as follows:

if a disruptive discharge occurs at the first test while increasing of test voltage, a second test is performed.

If a second disruptive discharge occurs in the same compartment before reaching the highest level, there are two possibilities:

- If the second disruptive discharge is higher than the first voltage again the voltage is immediately increased. If a new discharge occurs the value of which is again higher, a new test will be carried out.
- If the second disruptive discharge is lower than or equal to the first, the test is stopped and the compartmentdismantled.

The process is continued in order to reach the test voltage. If a disruptive discharge occurs at this voltage, there are two possibilities:

- if it is the first disruptive discharge in the compartment since the test was begun, voltage is again increased. If there is no other discharge, the test has been successful. The test is stopped and the compartment dismantled.
- if some discharge has previously occurred in this compartment during the increase in voltage, the test is stopped and the compartment dismantled.

Required test equipment

During the on site tests, the supplier shall provide all necessary test facilities and equipment (such as high voltage test kit) for the switch-gear power frequency tests, i.e. test bushing or test cable, test adapter, test transformer or resonant test set etc. based on the voltage level of the GIS on returnable basis. For installation of HV test bushing suitable space shall be kept near to GIS. Cable termination chamber shall have suitable adapter arrangement to inject the HV test probe.

6.14. MANDATORY SPARS: Design, engineering, manufacture, testing, supply on FOR destination site basis including transportation & insurance, storage at site of Mandatory spares for the GIS. Standard list of Mandatory Spares **shall be provided as per the BPS.**

16.15 SAFETY:

To ensure safety of personnel during maintenance, the GIS and switch room shall be arranged to facilitate safe and direct personnel access to all locations as follows:

1. Electrical and mechanical points of control of the GIS (disconnectors, earthing switches and circuit breaker mechanical trip mechanism)
2. Mechanical position indication of circuit breakers
3. Mechanical position indicators of disconnectors and earth switches
4. Inspection windows to verify position of disconnectors and earth switches
5. Gas density monitors, pressure transducers and filling points
6. Circuit breaker spring status mechanical indication
7. Current transformer secondary connection terminal boxes
8. Voltage transformer secondary connection terminal boxes
9. Already fitted PD monitors

Where the layout consists of two or more bays coupled to each other via the busbar, the busbar shall incorporate an additional buffer or spacer compartment to allow movement of personnel in between the bays to access any components located to the side of bays to carry out the activities 1 to 8 as listed above.
The additional buffer compartment shall be provided where the proposed equipment does not provide an access route between the bays. The buffer or spacer compartment shall be suitably sized such that a minimum of 1000 mm width spacing is provided between bays to allow access and movement of persons carrying out operations, regular inspection and maintenance tasks. Where the Customer proposes to supply free standing LCC's, the cabinets shall be free standing positioned over a cable ope or floor opening to accept the low voltage control cabling. The cabinet shall be swing frame type with door opening outwards to the left-hand side. All points of control shall be located on the front of the cabinet to allow operation and inspection without stepping inside the cabinet. The interior of the cabinet shall be equipped with a light. Removable gland plates shall be labelled with permanent stickers identifying the Safe Working Load (SWL) that the plate may bear. Adequate safety screens shall be provided for all moving parts. Provision shall be made for carrying out primary injection tests on all current and voltage transformers without requiring internal access to any gas compartment. The HV cable screen termination box in the HV cable room should be accessible from ground level.

16.14 TESTING & MAINTENACE EQUIPMENT

16.16.7 Special Tools

Any special tools needed for installation, operation and inspection shall be included in the quotation.
These special tools shall be supplied along with the GIS and shall not be taken back by the Tenderer. For gas handling purpose following tools shall be quoted as a minimum:

a) SF6 Gas Processing, Drying, Storage & Filling Unit
b) Online Partial Discharge Monitoring Unit
c) SF6 gas quality testing unit SF6 Gas Leak Detector
d) Precision Pressure Gauge with red & green zone marking.
e) SF6 Gas Evacuation Plant (One mobile cart and one static cart)
f) Video Borescope

Testing & Maintenance equipment shall be offered, as per BoQ.

16.16.8 SF6 Gas Leakage Detector.

The detector shall be portable, battery operated, hand held type and having a minimum SF6 gas leakage sensitivity of 5gm/year. The detector shall be lightweight, cordless unit able to detect SF6 leaks in seven different sensitivity levels with a response rate of one second. The sensor shall be connected through a flexible wand for easy accessibility to joints, seals and couplings in GIS equipment and provided with a protection filter. The equipment shall have on/off switch & suitable indicating lamps/LEDs, variable pitch audible signal for leakage indication. The equipment shall have automatic zeroing of background signals suitable for detecting SF6 gas leakage in charged switchyard. The test kit shall be compatible for EMI/EMC environment as per IEC 1000. **The leakage data shall be clearly presented on an LED display. The detector should be temperature compensated**.

16.16.9 Gas filling and evacuating plant : (Gas Processing unit)

- The plant necessary for filling and evacuating the SF6 gas in the switchgear shall be supplied to enable any maintenance work to be carried out. This shall include all the necessary gas cylinders for temporarily storing the evacuated SF6 gas. The capacity of the temporary storage facilities shall at least be sufficient for storing the maximum quantity of gas that could be removed from at least one phase of one complete bay (switchgear and associated equipment).
- Where any item of the filling and evacuating plant is of such a weight that it cannot easily be carried by maintenance personnel, it shall be provided with lifting hooks for lifting and moving with the overhead cranes.
- The minimum capacity parameters of evacuation plant will be as

  under : Oil Free Suction (Recovery) Pump: 30

  M^3/Hour

  Compressor (Two Stage): 15 M^3/Hour

  Oil Free Vacuum Pump: 100 M^3/Hour
- The evacuation equipment shall be provided with all the necessary pipes, couplings, flexible tubes and valves for coupling up to the switchgear for filling or evacuating all the gases.

  Details of the filling and evacuating plant that will be supplied, as well as the description of the filling and evacuating procedures shall be furnished.
- The service cart shall be designed for emission free gas handling with the couplings. Touch screen facility shall be present. Indication units such as bar/mbar, kPa or psi/torr etc. shall be selectable in the touch screen.

16.16.10 SF6 Gas Analyzer:

a. In-built calibration facility.
b. Sensitivity of the equipment shall not be affected by any atmospheric conditions like dust, humidity, heat, wind etc.
c. Equipment shall work on zero gas loss principle i.e. gas should be pumped back to the compartment after measurement without any exposure to the atmosphere.
d. Equipment shall be supplied with suitable regulator which can be used to connect SF6 cylinder if required.
e. Following acidic/impurities products should be detected as per IEC 60480 and IEC 60376
i) SF6 purity – Range: 0-100 % & Accuracy: +/- 2 deg C
ii) Dew point - Range : -60 to +20 deg C & Accuracy: +/- 2 deg C (to> -40 deg C); +/- 3 deg C (to<-40 deg C)
iii) SO2 - Range : 0-150 ppm & Accuracy : +/- 2 %

iv) HF - Range : 0-10ppm & Accuracy : +/- 10 %

f. Instrument should work on AC source as well as on rechargeable battery without causing any data loss. Also, provision for downloading the data shall be provided.

g. Input pressure: upto 10 bar

h. It should be housed in a robust IP67 case with wheels

i. User Interface: USB/LAN/Wifi

j. Data storage: Minimum 1000 measurement values shall be stored

k. Sensor modules should be field exchangeable.

l. Battery must be easy to exchange (max 5 min duration)

16.16.11 Online Partial Discharge Monitoring System

- GIS equipment shall be designed so as to minimize partial discharge or other electrical discharge. A state-of-the art Partial Discharge Monitoring system shall be provided to monitor the entire GIS installation.
- An on-line continuous Partial Discharge Monitoring (PDM) system shall be designed to provide an automatic facility for the simultaneous collection of PD data at multiple points on the GIS & its associated GIB ducts and Voltage Transformers and SF6 to Air bushing and cable termination module adopting UHF technique. The data stored shall provide a historical record of the progress of PD sources and shall identify the areas of maximum activity.
- On-line continuous Partial Discharge Monitoring (PDM) system shall be capable for measuring PD in charged GIS environment as EHV which shall have bandwidth in order of 100 MHz–2GHz with possibility to select a wide range of intermediate bandwidths for best measurement results. The principle of operation shall be based on UHF principle of detection.
- The scope shall cover Engineering, supply, installation, testing and commissioning of partial discharge continuous monitoring system, with all necessary auxiliaries and accessories to make a complete system as per technical specification, including site demonstration of successful operation. Any items/accessories necessary to make the system fully functional for the trouble free online PD monitoring of complete GIS installation shall be considered as included in the scope.
- The PDM system shall be provided with all its hardware and software, with readily interfacing to the UHF PD couplers installed in the GIS of present bays and future bays as shown in SLD plus 20% additional as extra. Details of this shall be submitted during engineering stage for approval.
- The integration of UHF PD coupler in future GIS bays shall be done in respective package. The number of UHF PD coupler for future bays shall be decided based on GIS layout finalized under present scope (considering present GIS equipment with future provision).
- The PD Monitoring PC Work Station shall be housed in a lockable cabinet with duplicate keys and shall be located in the control room of the GIS substation. Workstation PCs shall be pre-loaded with all necessary Hardware & Software. The PCs shall have each Combo drive & Retrievable disk drive (1 TB), Ethernet port 100Mbps, printer, and spare slots for hot-pluggable hard disks to extend the storage capacity. The workstation PC and all equipment & cabinets shall be powered by suitable dedicated UPS of adequate rating and same is included in the present scope.
- Design of on-line PDM System
    1. The technical proposal for PDM system along with detailed design documentation shall be submitted for EMPLOYER'S approval during engineering stage.
    2. To guarantee that sufficient coverage is available for complete GIS installation to monitor PD activity all design details shall be submitted as part of the above for review.

3. The sensitivity of the offered system shall be in accordance with CIGRE Document No. 654 that will be verified as part of site sensitivity tests.
4. UHF attenuation data of GIS shall be submitted for the switching devices, spacers, bends etc.
5. The signal attenuation level of co-axial cable per meter length and justification forthe length of cable connection between the couplers and detector units shall be furnished.
6. The overall sensitivity of PD detection system shall take into account the spacing between couplers and the associated cabling, filters, amplifiers, etc.
7. The Sub-station GIS layout as a separate drawing indicating position of spacers, spread over of PD sensors with distance, sensor identification, the detector unit identification etc. shall be submitted during engineering stage for approval.
8. The PD sensors shall be identified / coordinated with the corresponding detector unit etc. with proper identification labeling and indicated in the substation PDM SLD.
9. Internal arrangement/wiring diagram is to be submitted for detector units/control cabinet etc. All internal items are to be identified / labeled to facilitate troubleshooting.
10. Supply requirement (AC & DC) to be specified for the complete monitoring system.
11. Power supply to PDM PC shall have protection against surges, overload and short circuit. A dedicated on-line UPS system shall also be provided as a backup during supply interruption, to ensure trouble-free & reliable running of the PDM System fora minimum of 15 minutes duration. Ratings of UPS shall be proposed for the approval of EMPLOYER'S. The UPS shall have enough capacity to initiate a 'safe' shut down of the PDM PC and the peripherals after this 15-minute period if normal supply fails to resume. The PDM PCs shall restart automatically on resumption of normal supply. The UPS shall not generate spikes during changeover of supply. UPS shall automatically give indication / alarm when it requires battery replacement. Potential Free Contacts shall be generated to signal these events. These contacts shall be wired out to Annunciation / Monitoring systems. Alternately, inverter of suitable capacity is also acceptable. Critical Process and Status alarms of the PDM system shall be displayed.
12. PDM System shall be provided with a user security for accessing the system with a
    log-on and password entry procedure. The user levels shall be defined as a Master User and other users for the modification of system, update, and entry of parameters or manual operation. System shall be able to generate 3D point on wave pattern whenever any PD activity detected by the system. System shall be able to give online 3D point on wave pattern, online PRPD (phase resolved PD) and online short time trend etc. System shall be able to generate the all the logs related to system fault, system access, PD event, and any changes in system setting etc.To guarantee a proper synchronization at all time, there shall be a minimum of 4 synchronization-inputs and the PDMS shall provide a facility to automatically select one of the active synchronization signals. The control software shall be able to generate the all the logs related to system fault (including skipped MCBs, overvoltage protection, faultycommunication and the connection to each frequency converter unit)
13. Method of electrical isolation/protection provided between PD sensor and detector circuitry in case of flashover/high potential stress inside GIS should be furnished.
14. The selected mode of propagation of PD signal (electromagnetic wave) inside GISfor the design of sensors shall be furnished.
15. The protection available for electronics against transient over voltages caused byswitching operations shall be furnished.
16. The capacity of each detector unit to be specified to accommodate as many numbers of PD sensors signal.
17. The applicable standards to meet IEC & IEEE requirements for electromagnetic

compatibility shall be specified. The offered system should have been tested for the same for working in a 400kV & above substation environment. The necessary documentation has to be submitted in this regard.

18. Guaranteed technical particulars & data sheet for various components used in the system shall be submitted.
19. A redundant fibre optic ring network shall transmit the measurement data from all acquisition units to the PDMS control cabinet. The communication between the acquisition units and the server/control cabinet shall be TLS encrypted.

- **Calibration:** The UHF Couplers have to be first calibrated as per CIGRE procedure TF 15/330305 as part of factory acceptance tests to guarantee detection sensitivity of 5pC or better. The GIS of same design shall be used as test specimen during the coupler calibration. The pulse injection level determined through above factory calibration tests shall only be used as reference for site sensitivity checks during commissioning of PDM system. The data sheet/frequency response characteristics shall be submitted for reference.

- **Every Day Use & Maintenance** : The system shall be designed suitable for an unmanned s/s and operate automatically. The system shall generate alarms if suspected partial discharge activity is noticed or the system itself is in failure, thereby eliminatingthe necessity of periodic system access by the user and one such alarm shall be connected to Substation automation system (SAS). The alarms shall be configured coupler wise.

- **Computers and Peripherals: Computers and Peripherals: The PC operating system shall be the latest version of MS Windows/LINUX**. It should be suitable for continuous process application and should have been tested for the same. The hardware configuration of PC should be the latest available inthe market of industrial type subject to EMPLOYER'S / Engineer approval. For storing the historical PD database, sufficient storage facility in the form of hard disc and retrievable hard disk drive of 1TB as specified shall be available in the substation. ThePC monitor shall be 21" LCD type of reputed make.

- **Filtering Facility:** The filtering facility has to be provided in order to distinguish real PD from internal/external noise such as switching operations, self-test signal, radio, communication signal etc. The PDM system itself shall be able to discriminate the noise from real PD. The exposed gas barriers of the GIS shall be shielded effectively against noise interference & tested. The gas barrier shields/belts shall be suitable for outdoor use also & able to withstand high ambient temperature. Site measurements have to be performed after installation of the PDM system in order to identify the various sources of external noise to incorporate the same in the filtering facility. This filtering will preferably be through software by band pass, which can be manually activated (as an option) to filter out noise signals in the trend plot display. If hardware filtering is employed then adequate measures have to be taken to avoid masking of other signals, which may lie in the same frequency range. The method adopted for the above shall be specified taking into account the sensitivity requirement of PDM system as per CIGRE document. The noise filters shall be selectable individually coupler-wise.

- **Self-Test (Diagnostic) Facility**: Built-in self-checking facility shall be incorporated in the control system which will continuously verify the correct operation of the whole monitoring system with the simulated PD signal viz. checking of the sensitivity of individual detector units, response of PD sensors in addition to the checking of the system functioning. The periodicity of such self-check operation shall be specified. In case of system failure this shall trigger an alarm for communication to SAS. External check facility: Propose the arrangement/device available for externally checking the healthiness of PD sensors by pulse injection in addition to built-in monitoring facility.

- **Detector Units:** The sensitivity of each detector unit shall be furnished. The sensitivity level of individual detector units shall be selectable depending on the site background noise level.

- **Trend Plot:** The trend plot facility shall be available with the update period of hourly/daily/weekly/monthly/yearly. It shall be possible to view the historical trends for the complete archived data accumulated over several years.

- **PD Monitoring modes**: There shall be two different modes of system operation viz. a dedicated Continuous PD Monitoring mode for the normal day today operation of the system & a dedicated HV commissioning test mode which is exclusively for PD monitoring during HV commissioning test. The HV commissioning mode shall also operate as an independent feature.

In the HV Commissioning mode the real time display shall be possible for a minimum of two complete bays with associated bus bars and at with one second update period. The HV test software shall automatically record the HV voltage information along with PD so as to check PD inception & extinction voltages precisely. The complete HV & PD data recorded during HV test shall be possible to be reviewed in replay mode after the HV test.

- **Alarm Facility:** The PDM system shall generate alarm when action is required; viz. a) PD alarm (abnormal PD activity indicating a risk of failure) & b) PD system fail alarm to be connected to SAS.
- **Real Time Display:** The PDM system should have the facility of Real Time display, which will give an instant indication of PD activity coupler wise, with one-second-update period. The PDM system shall be able to capture the PD data triggered by associated switching operations of CBs & isolators.
- **Schematics: The** PDM system should have GIS schemes bay-wise incorporating PD sensor identification and location along with spacer location. The sectional view of typical bay arrangement of GIS showing active parts shall also be included as part of the PDM software.
- **Print Option/Facility:** PDM system should have the option/facility of printing all trend plots/reports/POW patterns/displays, etc. Laser Colour printer shall be provided for this purpose at substation.
- **Data Archives:** This is to provide access to historical data and file storage with date and time stamp. Sufficient storage facility shall be available to review historical data updated for the lifetime of switchgear. The substation & headquarters PCs shall have a backup device in the form of a retrievable disk drive of 1TB capacity for this purpose.
- **PD Fault Identification & Location/Pattern Recognition/Predictive Maintenance**

  Diagnostic Software: In order to interpret various types of PD defects, intelligent diagnostics software (expert system) shall be built- in as part of the PDM software capability. This is mainly to reduce the dependence on PD specialist. The bidder shallalso make available typical point-on-wave patters as library pictures to train the user.

  Software Updates: It shall be possible to upgrade / update the system software throughout the lifetime of the system with the ongoing development / refinement in PD technology.
- **Fault investigation**: In case of any indication of suspected PD activity by the on line system, further investigation has to be carried out by the contractor for the PD defect identification and location during the warranty period
- **Special Tools / equipment, Spare Parts, software packages**
- **Special Tools:** Special tools for cutting and crimping of coaxial cable with ‘N Connectors’ shall be supplied.
- **Spare parts:** The contractor has to supply critical spares with replacement procedure for the trouble-free operation of the system during its expected lifetime as part of the contract. A detailed list shall be included in the tender and also submitted for EMPLOYER’S approval during the detailed engineering stage.
- **Software Packages:** The complete software package shall be supplied as part of a back-up facility in the form of DVD/CDs viz. Windows operating system with end user license, PDM Software including HV Test, Drivers for modems etc., software for remote access, printer etc. The list shall be submitted for reference.

Pulse generator for UHF sensor sensitivity test shall also be supplied as a standard accessory.

- **Operation & Maintenance Manual**: A complete O&M manual covering all aspects of trouble shooting of PDM system in six sets in original shall be provided & also in CD's. For diagram references colour pictures shall be provided. A step-by-step procedure for spare parts replacement shall also be included.
- **Factory / Site Test Formats**: The factory & site tests format to be submitted for approval. The format shall cover all possible tests to confirm healthiness of the system and to record the test values.
- **List of References**: List of References: The bidder shall provide a reference list of PD monitoring system having field proven experience of the offered model, which is supplied by them and in successful operation worldwide in a power utility for at least 5 years.
  "The OEM should be having more than 20 years of experience in working with UHF based technology of PD monitoring and at least 10 years of experience in selling UHF based PD monitoring products to various electric utilities .The OEM must have supplied at least 5 (five) Online UHF PD monitoring system to different power utilities in India in last 10 (ten) years for the GIS ratings 400kV and above. The OEM must have their own direct established service Centre in India with certified on–roll service engineers equipped with proper tools & tackles to response to any sort of service issues locally, for which documentary evidence like service order copy/AMC copy released by Government utility/PSUs in the last 5 years, which should be on the name of OEM, shall be submitted along with the bid. They must have local on-roll experts to provide the technical support time to time."

Video Borescope:

- LCD: 16.25 cm (6.4 in) diagonal active-matrix VGA color LCD
- Display Resolution: 640 x 480px
- Sunlight Readable: 1100 Cd/Msquared
- Mounting: 75 x 75 mm (1/4-20) and vesa mount
- Battery Life (continuous): 6 to 8hrs (integrated), 3600 mAh rechargeable battery
- Frame Rate: 30fps (NTSC & PAL)
- Video / Image Transfer: SD Card or USB
- Camera Diameter Range: 25mm
- Camera Focal Length Options: Long View and Short View Macro
- Camera Length Range: 30m
- Video resolution: 960x480 (avi format) (with sound)
- Image Resolution: 640x480 (jpeg format)
- Memory: Internal 4GB, 16 GB SD card (expandable to 32 GB)
- Transmission frequency: 2.4GHz
- Transmission Range: 32ft (10m) unobstructed view
- Viewing direction: Viewing angle 110 degree
- Power: AC: 90-264 Vac, 47-63HZ, <1.2 A rms @90Vac
- DC: 10.2V +5/-3%. 4.9A
- Tip Operating Temp: -25°C to 100°C (-13°F to 212°F) Reduced articulation below 0°C (32°F)
- System Operating Temp: -20°C to 46°C (-4°F to 115°F)
- Storage Temperature: -25°C to 60°C (-13°F to 140°F)
- Relative Humidity: 95% max, non-condensing
- Waterproof: Insertion tube and tip to 14.7 psi (1 bar, 10.2m of H_2O, 33.5 ft of H_2O)
- Ingress Protection: IP67
- Joystick Control: 360° All-Way® tip articulation, bump gesture, menu access and navigation
- Button Set: Access user functions, measurement and digital functions
- Audio: Integrated 2.5mm headset/microphone jack
- Data I/O Ports: Two USB 2.0 ports
- Brightness Control: Auto and Variable
- Illumination Type: White LED

- Long Exposure: Via auto and manual mode
- White Balance: Factory default or user defined
- Operating System: Real-time multi-tasking operating system
- User Interface: Simple drop-down menu-driven operation Menu navigation using articulation joystick
- File Manager: Embedded file manager software supporting: File & Folder creation, naming, deleting, Store to internal Flash (C:\) or USB Thumb Drive Copy between USB and C:\
- MDI Software : Provides user defined guided inspection, Creates DICONDE compatible inspection files, Creates MS Word™ compatible inspection reports.
- It shall be electrostatic and electromagnetic interference proof.
- Audio Data: PC compatible (.mp3) file format
- Image Control: Invert, Zoom (5X digital) Image Capture and Recall
- Digital Zoom: Continuous (5.0X)
- Image Formats: Bitmap (.BMP), JPEG (.JPG)
- Video Format: AVI
- Text Annotation: Built-in full screen text overlay generator, 100 text line capacity
- Graphic Annotation: User placement of arrows
- Articulation Control: "Steer & Stay" articulation lock/fine articulation
- Tip "Home" return to neutral forward-tip orientation
- User-selectable fine or coarse control XpertSteer probe articulation offers quick steering responsiveness for tight probe control bump steering enables slight adjustments to probe position
- Software Updates: Field updateable via USB Thumb Drive
- Languages: English
- Boost function improved image quality in dark environments
- Illumination: 12 white LEDs

TRAINING:

The successful bidder shall organize a 15 (official) days training program at GIS manufacturer's end for 10 numbers of AEGCL engineers **at free of cost** making understand all the key points related to the design of GIS and shall also highlight the maintenance issues related to GIS and steps to tackle them. The GIS manufacturer shall provide a detailed training to the AEGCL engineers. Further, the successful bidder shall organize an on-site GIS training program also for 10 (official) days for 20 AEGCL engineers **at free of cost** where the GIS manufacturer will provide necessary training for on-site testing and all other key points related to GIS erection, operation and maintenance.

The successful bidder shall also organize an on-site training program for 7 (official) days for 20 numbers of AEGCL engineers at free of cost for GIS handling and maintenance equipment for familiarizing the handling equipments with the AEGCL engineers. The manufacturer of each GIS maintenance equipment (as mentioned in the BoQ) shall provide necessary training regarding operation and maintenance of the gas handling and other equipments

GTP of GIS CIRCUIT BREAKER

Sl.No.	Parameter	400kV system	220kV system	132 kV system
1.	Rated voltage (Umax) kV (rms)	420	245	145
2.	Rated frequency (Hz)	50	50	50
3.	No. of poles	3	3	3
4.	Type of circuit breaker	SF6 gas insulated	SF6 gas insulated	SF6 gas Insulated
5.	Rated continuous current (A) at an ambient temperature of 50^0C	4000	3150	3150
6.	Rated short circuit capacity with percentage of DC component as per IEC-62271-100 corresponding to minimum opening time under operating conditions specified.	63kA	50 kA	40kA
7.	Symmetrical interruptingcapability kA (rms)	63kA	50kA	40kA
8.	Rated short circuit makingcurrent kAp	157.5	125	100
9.	Short time current carrying capability kA (rms)	63kA for 3 sec	50kA for 3 sec	40kA for 3 sec
10.	Out of phase breaking currentcarrying capability kA (rms)	15.75	**As per IEC**	**As per IEC**
11.	Rated line charging interrupting current at 90 deg. Leading powerfactor angle (A rms) (The breaker shall be able to interrupt the rated line charging current with test voltage immediately before opening equal to the product of U/□3 and 1.4 as per IEC-62271-100	600	As per IEC	As per IEC

12.	First pole to clear factor	1.3	1.3	1.3
13.	Temperature rise over an ambient temperature of 50^{0}C	As perIEC: 62271-100	As per IEC: 62271-100	As per IEC: 62271-100
14.	Rated break time as IEC (ms)	40	60	60
15.	Total break time (ms)	45	65	65
16.	Total closing time (ms)	Not more than 80	Not more than **100**	Not more than **100**
17.	Operating mechanism or a combination of these	Spring	Spring	Spring
18.	Rated operating duty cycle	O-0.3s-CO-3 min-CO	O-0.3s-CO-3 min-CO	O-0.3s-CO-3 min-CO
19.	Reclosing	Single phase &Three phase autoreclosing.	Single phase &Three phase auto reclosing.	Three phase auto reclosing. (Single phase auto reclosing if specified in section-project)
20.	Pre-insertion resistor requirement	As per BPS	NA	NA
i)	Rating (ohms)	400(max.)with tolerance	NA	NA
		as applicable		
ii)	Minimum electrical (mechanical insertion time +pre-arcing time) pre-insertion time (ms)	8	NA	NA

21.	Max. difference in the instants ofclosing/opening of contacts (ms) between poles at rated control voltage and rated operating & quenching media pressures	2.5(within a pole) 3.3(opening) 5.0(closing)	3.3(opening) 5.0(closing)	3.3(opening) 3.3(closing)
22.	Maximum allowable switching over voltage under any switching Condition	2.3 p.u.	As per IEC	As per IEC
23.	Trip coil and closing coil voltagewith variation as specified	220V DC	220V DC	220V DC or 110V DC
24.	Noise level at base and up to 50 m distance from base of circuit breaker	140dB (max.)	100dB (max.)	80dB (max.)
25.	Rating of Auxiliary contacts	10A at 220V DC	10A at 220V DC	10A at 220V DC
26.	Breaking capacity of Aux.Contacts	2A DC with circuit time constant not less than 20ms	2A DC with circuit time constant not less than 20ms	2A DC with circuit time constant not less than 20ms
27.	**Rated insulation levels**			
i)	Full wave impulse withstand(1.2 /50 µs) between line terminals and ground	□1425 kVp	□1050 kVp	□650 kVp
ii)	Full wave impulse withstand(1.2 /50 µs) between terminals with circuit breaker open	1425 kVp impulseon one terminal& 240	□1050 kVp	+ 650kVp
		kVp power frequency voltage of opposite polarity on the other terminal		
iii)	Rated switching impulse withstand voltage (250/2500 µs) Dry & wet between line terminals andground	+1050 kVp .	NA	NA

iv)	Rated switching impulsewithstand voltage (250/2500 µs) Dry &wet Between terminals with circuit breaker open	900 kVp impulse on one terminal& 345 kVp power frequency voltage of opposite polarity on the other terminal	NA	NA
v)	One minute power frequency drywithstand voltage between line terminals and ground	520 kV rms.	460 kV rms.	275 kV rms
vi)	One minute power frequency drywithstand voltage between terminals with circuit breaker open	650 kV rms.	460 kV rms.	275 kV rms
28.	Minimum corona extinction voltage with CB in all positions	320kV rms	156 kV rms	92 kV rms
29.	Max. radio interference voltage for frequency between 0.5 MHzand 2 MHz (Micro volts)	1000 µV (at 266kVrms)	1000 µV (at 156kV rms)	500µV (at 92kV rms)
30.	System neutral earthing	Effectively earthed		
31.	Auxiliary contacts	Besides requirement of technical specification, the manufacturer/contractor shall wire up 10 NO +10 NC contacts exclusively for purchaser's use and wired up to common marshalling box. (LCC)		
32.	No. of terminals	All contacts & control circuits to be wired out up to common marshalling box + minimum 24 terminals exclusively for purchaser's future use		

GTP of GIS DISCONNECTORE/ISOLATORS

Sl. No	Particulars	400 kV	220 kV	132kV
1.	Rated voltage (rms)Un	420 kV	245 kV	145 kV
2.	Rated frequency	50 HZ	50 HZ	50 Hz
3.	System earthing	Effectively earthed	Effectively earthed	Effectivelyearthed
4.	Type	SF6 insulated	SF6 insulated	SF6 insulated
5.	Rated continuous current (A) at 50^{0}C ambient temp.(as applicable)	4000	3150	3150
6.	Rated short time withstand current of isolator and earth switch(as applicable)	63 kA for 3 Sec.	50kA for 3 Sec.	40 kA for 3 second
7.	Rated dynamic short circuit withstand current withstand current of isolator and earth switch(As applicable)	157.5 kAp	125 kAp.(As applicable)	100 kAp
8.	Rate d insulation level:			
	One minute power freq. Withstand voltage: To earth :	650 kV rms.	460 kV rms.	275 kV rms.
	One minute powerfreq. Withstan d	815 kV rms.	530 kV rms.	315 kV rms.

	voltage: Acros sisolating distance			
	1.2/50 micro sec. Lighting impulse withstand voltage (+ve or –ve polarity) To earth:	1425 kVp	$\pm$1050 kVp	650kVp
	1.2/50 micro sec. Lighting impulse withstand voltage (+ve or –ve polarity) : Across Isolating distance	$\pm$1425/-+240 kVp	1200 kVp	As per IEC
	Rated switching impulse withstand voltage (250/2500 micro-sec.) Dry & wet :between line terminals an dground:	+/- 1050 kVp	N.A	N.A
	Rated switching impulse withstand voltage (250/2500 micro-sec.) Dry & wet :Betwee n terminals with Isolator open:	+/- 900 kVp impulse on one terminal & 345 kVp of opposite polarity on the other terminal.	N.A	N.A
9.	Mechanical Endurance claus eas per IEC	M2	M2	M2
10.	No. of spare auxiliary contacts on each isolator	4 NO and 4 NC	4 NO and 4 NC	4 NO and 4 NC
11.	No. of spare auxiliary contacts on each earthing switch	4 NO and 4 NC	4 NO and 4 NC	4 NO and 4 NC

GTP OF GROUNDING SWITCHES					
SL. NO	**SYSTEM PARAMETERS**	**UNIT**	**RATING**		
			400	**220**	132
I	**II**	**III**	**IV**	**V**	VI
1	Rated Voltage	Kv	420	245kV	145
2	Lightning impulsewithstand voltage against ground	kV	1425	1050	650
3	Lightning impulse withstand voltage across isolating distance	kV	Lightning Impulse: As per IEC 62271-203		
4	Power frequency withstand voltage against ground	kV	650	460	275
5	Power frequency withstand voltageacross isolating distance	Kv	Power frequency: As per IEC 62271-203		
6	Nominal operating current	A	4000	3150	3150
8	Number of poles		3		
9	Dynamic current	kA	157.5	125	100
12	Rated short-circuitwithstand current (r.m.s.), 3s	kA	63	50	40
13	Type of operating mechanism		Motor operation		
14	Number of drives per3 phase		1		
15	Control voltage (DC)	V	220 DC		
16	Number of CO operations permissiblewithout maintenance	No.	As per latest IEC standard		

HIGH SPEED EARTH SWITCH					
SL.NO	SYSTEM PARAMETERS	UNIT	RATING		
			400	220	132
I	II	III	IV	V	VI
1	Rated Voltage	kV	420	245	145
2	Lightning impulse withstand voltage against ground	kV	1425	1050	650
3	Lightning impulse withstand voltage across isolating distance	kV	Lightning Impulse: As per IEC 62271-203		
4	Power frequency withstand voltage against ground	kV	650	460	275
5	Power frequency withstand voltage across isolating distance	Kv	Power frequency: As per IEC 62271-203		
6	Nominal operating current	A	4000	3150	3150
7	Inductive current switching capability	A , kV	As per IE C standard		
8	Capacitive current switching capability	A , kV	As per IEC standard		
9	Number of poles		3		
10	Dynamic current	kA	157.5	125	100
11	Rated short-circuit withstand current (r.m.s.),	kA	63	50	40

	3s				
12	Type of operating mechanism		Motor operation		
13	Number of drives per3 phase		1		
14	Control voltage (DC)	V	220 DC		
15	Short-circuit making:	Class	E1		
16	Number of CO permissible without maintenance	No.	As per latest IEC standard		

CURRENT TRANSFORMERS

S. No.	Description	765kV System (NA)	400kV system	220kV system	132 kV system
1	Rated voltage, U_m (kVrms)	800	420	245	145
2	Rated frequency (Hz)	50	50	50	50
3	No. of Poles	1	1	1	1
4	Design ambient temperature(°C)	50	50	50	50
5	Rated Primary Current (A)	3000	As per schedule of requirement		
6	Rated extended primarycurrent	120%	120%	120%/150 %	120%/150%
7	Rated short time thermalwithstand current	50kAfor 1 sec	63k A for 3 sec	50kAfor 3 sec	40 kA for 3 sec
8	Rated dynamic current	125kAp	157.5kAp	125kAp	100kAp
9	Temperature rise over designambient temperature	As per IEC			
10	Rated Insulation levels				
a)	Full wave impulse withstand voltage (1.2/50 microsecond)				

S. No.	Description	765kV System (NA)	400kV system	220kV system	132 kV system
i)	between line terminals andground(kVpeak)	±2100	±1425	±1050	±650
b)	Switching impulse withstand voltage (250/2500 microsecond) (dry and wet)				
i)	between line terminals andground (kVpeak)	± 1550	± 1050	-NA-	-NA-
c)	One minute power frequency dry withstand voltage (dry and wet)				
i)	between line terminals andground (kVrms)	975 (dry only)	650 (dry only)	460	275
d)	One minute power frequencywithstand voltage between secondary terminals & earth (kVrms)	5kV			
11	Max. radio interference voltage for frequency between0.5 MHz and 2 MHz	2500 at 508 kV rms	1000 at 266kV rms	1000 at 156kV rms	500 at 92kV rms
	at (microvolts)				
12	Minimum Corona extinction voltage (kVrms)	508	320	-NA-	-NA-
13	Seismic acceleration (Horizontal)	As per Zone-V			
14	Partial Discharge	As per IEC	As per IEC	As per IEC	As per IEC
15	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.			
16	System Neutral earthing	Effectively earthed			
17	Ratio and Accuracy class	As per project Reaquirement			

TECHNICAL PARAMETERS FOR VOLTAGE TRANSFORMERS

S. No.	Description	765kV System (NA)	400kV system	220kV system	132 kV system

1	Type (CVT/IVT)	**CVT**	**CVT/IVT**	**CVT/IVT**	**CVT/IVT**
2	Rated voltage, U_m (kVrms)	800	420	245	145
3	Rated frequency (Hz)	50	50	50	50
4	No. of Poles	1	1	1	1
5	Design ambient temperature(°C)	50	50	50	50
6	System fault level (kA)	50kA for 1sec	63kA for 3 sec	50kA fo 3sec	40 kA for 3sec
7	Standard reference range offrequencies for which the accuracies are valid	96% to 102% for protection and 99% to 101% for measurement			
7	High frequency capacitance forentire carrier frequency range (for CVT only)	Within 80% to 150% of rated capacitance			
8	Equivalent series resistance over entire carrier frequencyrange (for CVT)	Less than 40 Ohms			
9	Stray capacitance and stray conductance of HF terminal over entire carrier frequency range (for CVT)	As per IEC-60358			
10	Temperature rise over designambient temperature	As per IEC			
11	Rated Insulation levels				
a)	Full wave impulse withstand voltage (1.2/50 microsecond)				
i)	between line terminals andground (kVpeak)	±2100	±1425	±1050	±650
b)	Switching impulse withstand voltage (250/2500 microsecond) (dry and wet)				
i)	between line terminals andground (kVpeak)	± 1550	± 1050	-NA-	-NA-
c)	One minute power frequency dry withstand voltage (dry and wet)				
i)	between line terminals andground (kVrms)	975 (dry only)	650 (dry only)	460	275
d)	One minute power frequency withstand voltage between secondary terminals & earth				
i)	between LV (HF) terminal andearth terminal (kVrms)	10kVrms for exposed terminals and 4kVrms for terminals enclosed ina weather proof box			
ii)	For secondary winding	3kVrms			

11	Max. radio interference voltage for frequency between0.5 MHz and 2 MHz at (microvolts)	2500 at 508 kV rms	1000 at 266kV rms	1000 at 156kV rms	500 at 92kV rms
12	Minimum Corona extinction voltage (kVrms)	508	320	-NA-	-NA-
13	Partial Discharge	As per IEC	As per IEC	As per IEC	As per IEC
14	Number of terminals	All terminals of control circuits are to be wired up to marshaling box (LCC) plus 20% spare terminals evenly distributed on all TBs.			
15	Rated Total Thermal Burden(VA)	300 VA (100VA/winding)			
17	System neutral earthing	Effectively Earthed			

TECHNICAL PARAMETERS OF GIS SURGE ARRESTOR

Sl. No.	Description	Unit	800kV SA (NA)	420kV SA	245kV SA	145kV SA
1	Nominal Syste mOperating voltage	kV, rms	765	400	220	132
2	Rated frequency	Hz	50	50	50	50
3	No. of Poles	No.	1	1	1	1
4	Design ambient temperature	°C	50	50	50	50
5	Rated arrester voltage	kV	624	336	216	120
6	Continuous operating voltage at 50 deg.C	kV	490	267	168	102
7	Nominal dischargecurrent		20 kA of 8/20 microsecond wave	20 kA of 8/20 microsecond wave	10 kA of 8/20 microsecond wave	10 kA of 8/20 microsecond wave
8	Discharge current at which insulationco-ordination will be done		20 kA of 8/20 microsecond wave	20 kA of 8/20 microsecond wave	10 kA of 8/20 microsecond wave	10 kA of 8/20 microsecond wave

Sl. No.	Description	Unit	800kV SA (NA)	420kV SA	245kV SA	145kV SA
9	Minimum discharge capability (referredto rated arrester Voltage) or corresponding to minimum discharge voltage as per clause-2.0 (d) whichever is higher	kJ/kV	13kJ/kV	12kJ/kV	9kJ/kV	8kJ/kV
10	Max. switching surge residual voltage	kVp	1180 (at 1kA) 1220 (at 2kA)	670(at 2kA) 650 (at 500A)	500 (at 1kA)	280 (at 1kA)
11	Max. residual voltage at					
i)	5kA	kVp	-	-	560	310
ii)	10 kA nominal discharge current	kVp	-	800	600	330
iii)	20 kA nominal discharge current	kVp	1480	850	-	-
iv)	Steep fronted waveresidual voltage at 20 kA	kVp	1480	925	-	-
12	Long duration discharge class		5	4	3	3
13	High current shortduration test value(4/10 micro second wave)	kAp	100	100	100	100
14	Current for pressure relief test	kA rms	63	63	50	40
15	Low current long duration test value					

Sl. No.	Description	Unit	800kV SA (NA)	420kV SA	245kV SA	145kV SA
16	Insulation Level					
a)	Full wave impulse withstand voltage (1.2/50 microsec.)					
i)	Arrester Housing	kVpeak	As per IEC:60099-4	±1425	±1050	±650
b)	Switching impulse withstand voltage (250/2500 micro-second) dry and wet					
i)	Arrester Housing	kV peak	As per IEC:60099-4	± 1050	-NA-	-NA-
c)	One minute power frequency dry withstand voltage					
i)	Arrester Housing	kV rms	830	650	460	275
18	Partial Dischargeat 1.05 COV		≤ 10pC	≤ 10pC	≤ 10pC	≤ 10pC
19	System neutral earthing		Effectively Earthed	Effectively Earthed	Effectively Earthed	Effectively Earthed

TECHNICAL PARAMETERS FOR SF6/AIR BUSHING

Sl. No.	Particular	765 Kv (NA)	400 kV	220 kV	132kV
1	Rated Voltage (kV)	800 kV(rms)	420 kV (rms)	245 kV (rms)	145 kV (rms)
2	Rated Current (Amp)	2000/3150 as applicable	4000	3150	2500
3	1.2/50 micro second impulsevoltage (Lightning impulse withstand voltage)	2100 kVp	1425 kVp	1050 kVp	650 kVp
4	250/2500 micro second switching impulse voltage	1550 kVp	1050 kVp	-	

5	One minute power frequency withstand voltage	960 kV (rms)	650 kV (rms)	460 kV rms	275 kV (rms)
6	Minimum total Creepage distance in mm	31mm/kV	31mm/kV	31mm/kV	31mm/kV
7	Minimum Cantilever strength (kN)	10	10	8	8

CHAPTER 17: TECHNICAL SPECIFICATION OF TRANSFORMER (UPTO 400kV CLASS)

17.1.0 SCOPE:

17.1.1 This specification provides for design, manufacture, inspection and testing before dispatch, packing and delivery at destination sub-stations of transformers complete with all fittings, accessories, spares, unloading, handling, proper storage at site, associated equipments specified herein. The scope of work shall also include, supervision of Erection, Testing and Commissioning of all the equipments supplied under this specification.

17.1.2 It is not the intent to specify completely herein all details of the design and construction of equipments. However, the equipment shall conform in all respects standards of engineering, design and workmanship listed in clause no. 17.2.0 and shall be capable of performing in continuous commercial operation up to the supplier's guarantee in a manner acceptable to the purchaser, who will interpret the meanings of drawings and specification and shall have the power to reject any work or material which, in his judgment, is not in accordance therewith. The equipments offered shall be complete with all components necessary for their effective and trouble-free operation. Such components shall be deemed to be within the scope of supplier's supply, irrespective of whether those are specifically brought out in this specification and/or the commercial order or not.

17.1.3 The scope of supply includes the provision of training for Purchaser's personnel (Limiting to 10 Persons for minimum of 05 days duration) in regard to design, manufacture, assembly, testing, operation and maintenance of offered transformer at his works in the event of order, free of cost to AEGCL.

17.2.0 STANDARDS:

17.2.1.0 The Transformer and associated accessories shall conform to the latest issues of the standards as given below, except to the extent explicitly modified in this specification.

1	17.2.1.0	The Transformer and associated accessories shall conform to the latest issues of the standards as given below, except to the extent explicitly modified in this specification. (1) CBIP manual on Transformer. (2) 'Standard Specifications and technical Parameters for Transformers and Reactors (66 kV & above voltage class)' of CEA vide 'File No.CEA-PS-14- 169/2/2019-PSETD Division Dated: April, 2021' (3) Power Transformers (4) Fittings and accessories for power transformers (5) Insulating oils for transformers and switchgears (6) Bushings for alternating voltages above 1000 V (7) Gas operated relays (8) Code of practice for installation and maintenance (9) Colours for ready mix paints. (10) Industrial cooling fans. (11) Guide for loading of oil immersed transformers. (12) 'Guidelines for Model Quality Assurance Plan (MQAP) for major equipment of Power sector' of CEA	

17.2.1.1 In case equipment conforms to other international standard which ensure equivalent or better performance than that specified under **Clause 17.3.0,** then relevant extracts of the same shall be forwarded with the bid and the salient features of comparison shall be brought out separately in additional information schedule.

17.2.1.2 For further reference regarding standards **Annexure-V (List of Codes/Standards/ Regulations/Publications)** shall be followed.

17.3.0. GENERAL REQUIREMENT:

17.3.1.0 The transformers shall conform in all respects to high standards of engineering, design, workmanship and latest revisions of relevant standards at the time of offer and the purchaser shall have the power to reject any work or material which, in his judgment, is not in full accordance therewith.

17.3.1.1 The Transformer offered by the contractor shall at least conform to the requirements specified under relevant IS/IEC standard. In case of discrepancy between IS and other international standard, provisions of IS shall prevail. If the IS standard is not available, then other applicable international standard (IEC/Equivalent), as per the specification, shall be accepted.

17.3.1.2 The equipment to be supplied against this specification shall be suitable for satisfactory continuous operation under the tropical conditions mentioned in General Technical Requirement (GTR), of this bidding document.

17.3.1.3 The transformers shall in general have constant ohmic impedance between HV and IV on all taps. However, in case of transformer to be connected for parallel operation:

i) The percentage impedance, vector group, OLTC connection and range etc. of the transformers shall be matched.

ii) Necessary provision is to be kept in the transformer control scheme for parallel operation with the OLTC control scheme having provision of Master/Follower/Independent /Off operation etc.

iii) External or internal reactors shall not be used to achieve the specified HV/LV and IV/LV impedances.

17.3.1.4 The Transformer shall be multi-winding, oil immersed complying as per Specific technical parameters and suitable for outdoor installation.

17.3.1.5 The transformer of manufacturer having same or higher MVA rating and same or higher voltage class must be in successful operation in any STATE or CENTRAL utility for not less than five (5) years as on date of NIT.

	17.3.1.5	Rated Capacity and Voltage of the Transformers as per present requirement of AEGCL: a) 500 MVA – 400/220/33 KV Auto Trasformer with loaded 33 kV tertiary winding b) 160 MVA - 220/132/33 KV Auto Transformer with loaded 33 KV tertiary winding. **c) 50 MVA - 132/33 KV Power Transformer.**	

17.3.1.6 Components having identical rating shall be interchangeable.

17.3.1.5 Rated Capacity and Voltage of the Transformers as per present requirement of AEGCL:

a) 500 MVA - 400/220/33 KV Auto Transformer with loaded 33 KV tertiary winding.
b) 160 MVA - 220/132 KV Auto Transformer

17.4.0. SPECIFIC REQUIREMENT:

(i) Type Test:

The transformers should be Type Tested as per IS 2026 or IEC 60076 in conjunction with their relevant Part. Necessary test documents of previously tested similar or higher rated (both in MVA and voltage class) transformer shall have to be submitted with the bid.
Materials, which have never been tested for critical performance, shall not be accepted.
Type test certificates shall be acceptable only if: -

(a) Tests are conducted in an independent and well known (**NABL**/**BIS** Accredited) testing laboratory, or
(b) Tests are conducted in manufacturer's own laboratory. In this case,

(i) The laboratory must have ISO 9000 (or its equivalent) series certificatio, and
(ii)Tests have been witnessed by technically qualified representatives of earlier clients or purchaser.

Test reports to be acceptable must be related directly to the materials offered. **Type Test Reports of Power/Auto transformer older than five (5) years on the date of technical bid opening shall not be accepted**.
The Validity of Dynamic Short Circuit test report shall be as per CEA's notification no. CEA-TH-17/1/2021-TETD Division—dated 23rd December, 2022.
The Validity of type test report of Power/Auto Transformer and its accessories shall be as per CEA's "Guideline for Validity period of Type Tests conducted on Major Electrical Equipment in power transmission system", file No CEA-PS-14-80/1/2019-PSETD Division- Part (2).

Full Type Test Reports of at least the following equipment must be submitted: -

1. **500, 160, 100 and 50 MVA class Power/Auto Transformer**
2. **Tap Changer**
3. **Transformer Oil**
4. **Bushings**
5. **Buchholz Relay**
6. **Pressure Relief Device**
7. **Bushing Current Transformer**
8. **Oil Surge Relay**
9. **Cooling Gears**
10. **AVR Relay**
11. **On line drying system**

(ii) Dynamic Effect of Short Circuit:

For 400 kV Class Auto transformer

Bidder / Manufacturer should have successfully carried out Dynamic Short Circuit test on 315MVA or above rating 400/220/33kV or 400/230/33kV, 3- Phase Auto transformer as on the originally scheduled date of bid opening and shall enclose the relevant Test Report/certificate along with bid. In case bidder/manufacturer has not successfully tested 315MVA or above rating 400/220/33kV or 400/230/33kV, 3-Phase Auto transformer for Dynamic Short Circuit test, their bid shall be considered technically non responsive. **The offered transformer should comply the requirement of similarity clause specified in IS 2026 (PART 5) / IEC 60076-5 with respect to short circuit tested transformer**. Further, design review of offered 400kV Class Auto transformer shall be carried out based on the design of short circuit tested 315MVA or above rating 400/220/33kVor 400/230/33kV, 3-Phase Auto transformer.

For 220 kV Class Transformer:

Bidder / Manufacturer should have successfully carried out Dynamic Short Circuit Test on 160 MVA or above rating,220/132/33 kV Auto transformer as on the originally scheduled date of bid opening and shall enclose the relevant Test Report / Certificate along with bid. In case bidder has not successfully tested 220/132/33 kV, 160 MVA or above rating Auto–transformer for Dynamic Short Circuit Test, their bid shall be considered technically non-responsive. The offered transformer should comply the requirement of similarity clause specified in IS 2026 (PART 5) / IEC 60076-5 with respect to short circuit tested
transformer. Further, design review of offered transformer shall be carried out based on the design of short circuit tested transformer.

For 132 kV Class Transformer:

Bidder / Manufacturer should have successfully carried out Dynamic Short Circuit Test on 50 MVA or above rating, 132/33 kV Power transformer as on the originally scheduled date of bid opening and shall enclose the relevant Test Report / Certificate along with bid. In case bidder has not successfully tested 132/33 kV, 50 MVA or above rating transformer for Dynamic Short Circuit Test, their bid shall be considered technically non-responsive. The offered transformer should comply the requirement of similarity clause specified in IS 2026 (PART 5) / IEC 60076-5 with respect to short circuit tested transformer.
Further, design review of offered transformer shall be carried out based on the design of short circuit tested transformer.

(iii) Sweep Frequency Response Analysis (SFRA/FRA) shall have to be carried out as special test for each transformer at manufacturer's premises in presence of representative of AEGCL free of cost. Test result shall have to be handed over to AEGCL. Before commissioning of the Transformer at site, the same SFRA/FRA test will have to be carried by the test engineers of the manufacturer in presence of customer's representative for comparing the results to take the decisions of the commissioning. The Testing Engineers & FRA kit for such pre-commissioning site testing shall have to be arranged by the manufacturer free of cost.

(iv) Tests at Manufacturer's works: The Transformers shall be subjected to type & routine test, special tests and no load & load loss measurement as per relevant IS.

(v) Guaranteed Technical Particulars: The Bidder shall furnish all guaranteed technical particulars as called for in this specification along with each copy of Bid submission. Bids lacking information in this respect may not be considered.

(vi) Core Materials: Core materials should be directly procured from either the manufacturer or their accredited reputed marketing organization and not through any agent.

17.5.0. Guaranteed Technical Particulars

17.5.1.0 The Guaranteed Technical Particulars of the various items shall be furnished by the Bidders in the prescribed Schedules with the Technical Bid. The Bidder shall also furnish any other information's as in their opinion is needed to give full description and details to judge the item(s) offered by them.
17.5.1.1 The data furnished in Guaranteed Technical Particulars should be the minimum or maximum value (as per the requirement of the specification) required. A Bidder may guarantee a value more stringent than the

specification requirement. However, for testing purpose or from performance point of view, the material shall be considered performed successfully if it achieves the minimum/maximum value required as per the technical specification. No preference what so ever shall be given to the bidder offering better/more stringent values than those required as per specification except where stated otherwise.

17.6.0. Liquidated Damages and Rejection for Excessive Losses

17.6.1.0 The offered transformer shall not have any latent design defect within ten (10) years of commissioning.

17.6.1.1 The no-load losses, load losses and auxiliary losses shall not exceed the values specified in the **Maximum losses** Clause (i.e., Clause 17.6.1.3). No positive tolerance on no-load loss, load loss and auxiliary losses as well as total losses will be allowed. Any change in the figures assigned for transformer losses will not be permitted after opening of bids and evaluation will be carried out on the basis of information made available at the time of bid opening. Bid with higher losses as that of provided in the Technical Data Sheet, bid will be treated as non-responsive.

17.6.1.3 Maximum losses:

The maximum limit of losses shall be as per 'Standard Fixed Losses for Transformers and Shunt Reactors as per Central Electricity Authority (CEA) letter CEA/PSE&TD/218/3056-4028 dated 01.03.19'

Sr. No	Rating (MVA)	Voltage Rating (kV)	Phase	No Load Loss (kW)	Load Loss (kW)	I^2R (kW)	Stray + Eddy (kW)	Aux. Loss
1.	500	400/220/33	3- Phase	AT 90	500	375	125	15
2.	160	220/132	3- Phase	AT 30	200	145	55	6
3.	100	220/33	3- Phase	AT 43	245	200	45	5
4.	50	132/33	3- Phase	AT 25	125	105	20	3

17.7. Transportation

17.7.1 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.

17.7.2 The contractor shall carry out the route survey along with the transporter and finalise the detail methodology for transportation of transformer and based on route survey; any modification/ extension/ improvement to existing road, bridges, culverts etc. if required, shall be in the scope of the contractor.

17.7.3 The inland transportation of the Transformer shall be on trailers equipped with GPS system for tracking the location of transformer at all times during transportation from manufacturer works to designated site. Contractor shall monitor / track the location of the trailer on regular basis and also provide tracking details to respective site/employer at the time of despatch of Transformer from factory to designated site. Requirement of Hydraulic trailer is envisaged for a load of more than 40 T.

17.7.4 All metal blanking plates and covers which are specifically required to transport and storage of the transformer shall be considered part of the transformer and handed over to the Purchaser after completion of the erection. Bill of quantity of these items shall be included in the relevant drawing/document.

17.7.5 The Contractor shall despatch the transformer filled with dry air/N2 at positive pressure. The necessary arrangement shall be ensured by the contractor to take care of pressure drop of dry air/N2 during transit and storage till completion of oil filling during erection. A dry air/N2 pressure testing valve with necessary pressure gauge and adaptor valve shall be provided. Generally, the duration of the storage of transformer at site with dry air/N2, shall preferably be limited to three months, after which the Transformer shall be processed as per the recommendation of manufacturer if not filled with oil. The dry air/N2 cylinder(s) provided to maintain positive pressure can be taken back by the contractor after oil filling.
In case turret, having insulation assembly, is transported separately then positive dry air/N2 pressure shall be ensured.

17.7.6 The Transformer shall also be fitted with at least 2 numbers of **electronic impact recorders** (on returnable basis) during transportation to measure the magnitude and duration of the impact in all three directions. The acceptance criteria and limits of impact, which can be withstood by the equipment during transportation and handling in all three directions, shall not exceed “3g” for 50mSec (20Hz) or as per contractor standard, whichever is lower.

17.7.7 Vendor/EPC shall remove the electronic impact recorders after reaching the Transformer main foundation Location in front of AEGCL representative. Transformer manufacturer/EPC shall stop the electronic impact recorders and soft copy shall be handed over to AEGCL Site representative. EPC/Vendor shall return the electronic impact recorders to Manufacture factory, this hardcopies of report with the values (softcopy shall also be downloadable at site) to be submitted by Vendor at AEGCL Design cell/ Project Team.

17.8.0 Performance

17.8.1.0 The transformers shall be used for bi-directional flow of rated power. The major technical parameters of three phase transformer units are defined at **Annexure – A.**

17.8.1.1 Transformers shall be capable of operating under natural cooled condition up to the specified load. The forced cooling equipment shall come into operation by pre-set contacts of winding temperature indicator and the transformer shall operate as a forced cooling unit initially ONAF up to specified load and then as OFAF (or ODAF as specified). Cooling shall be so designed that during total failure of power supply to cooling fans and oil pumps, the transformer shall be able to operate at full load for at least ten (10) minutes without the calculated winding hot spot temperature exceeding 140 deg C. If the Transformer is fitted with two coolers, each capable of dissipating 50 per cent of the loss at continuous maximum rating, it shall be capable of operating for 20 minutes in the event of failure of the oil circulating pump or blowers associated with one cooler without the calculated winding hot spot temperature exceeding 140 deg C at continuous max rating. The contractor shall submit supporting calculations for the above and the same shall be reviewed during design review.

17.8.1.2 The transformer shall be free from any Electrostatic Charging Tendency (ECT) under all operating conditions and maximum oil velocity shall be such that it does not lead to static discharges inside the transformer while all coolers are in operation.

17.8.1.3 The transformers shall be capable of being continuously operated at the rated MVA without danger, at any tapping with voltage variation of +/-10% corresponding to the voltage of that tapping.

17.8.1.4 The transformers shall be capable of being over loaded in accordance with IEC-60076-7. There shall be no limitation imposed by bushings, tap changers etc. or any other associated equipment.

17.8.1.5 Tank hotspot shall not exceed 130 Deg. Celsius. Maximum ambient temperature shall be considered as 50 Deg. C.

17.8.1.6 The transformer and all its accessories including bushing/ built in CTs etc. shall be designed to withstand without damage, 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 2 secs. The short circuit level of the HV & **IV/LV** System to which the transformers will be connected is as follows:

400kV system - 63 kA for 3 sec (sym, rms, 3 phase fault)
220kV system - 50 kA for 3 sec (sym, rms, 3 phase fault)
132kV system - 40 kA for 3 sec (sym, rms, 3 phase fault)
33kV system - 31.5 kA for 3 sec (sym, rms, 3 phase fault)
However, for transformer design purpose, the through fault current shall be considered limited by the transformer self-impedance only (i.e., Zs = 0).

17.8.1.7 Transformer shall be capable of withstanding thermal and mechanical stresses caused by symmetrical or asymmetrical faults on any terminals. Mechanical strength of the transformer shall be such that it can withstand 3-phase and 1- phase through fault for transformer rated voltage applied to HV and / or IV terminals of transformer. The short circuit shall alternatively be considered to be applied to each of the HV, IV and tertiary (LV) transformer terminals as applicable. The tertiary terminals shall be considered not connected to system source. For short circuit on the tertiary terminals, the in-feed from both HV & IV system shall be limited by the transformer self-impedance only and the rated voltage of HV and IV terminals shall be considered. The maximum short circuit output current at the tertiary terminals shall be limited to a safe value to make the transformer short circuit proof. The transformer shall be designed to withstand **for through fault** short circuit duration of 2 seconds for Thermal stress and the same shall be verified during design review.

17.8.1.8 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 % continuous over-voltage condition it does not exceed 1.9 Tesla at all tap positions.

17.8.1.9 Transformers shall withstand without damage, heating due to the combined voltage and frequency fluctuations which produce the following over fluxing conditions:

110 % for continuous
125 % for 1 minute
140 % for 5 seconds

Withstand time for 150% & 170% over fluxing condition shall be indicated. Over fluxing characteristics up to 170 % shall be submitted.

17.8.1.10 The air core reactance of HV winding of transformer of 400 kV and above voltage class shall not be less than 20%. **External or internal reactors shall not be used to achieve the specified HV/IV, HV/LV and IV/LV impedances.**

17.9.0 Tertiary Windings (if applicable as per Annexure - A)

17.9.1.0 The tertiary windings shall be suitable for connection of reactors or capacitors which would be subjected to frequent switching and shall be suitable for connection to LT Transformer for auxiliary supply. All the windings shall be capable of withstanding the stresses which may be caused by such switching. The tertiary winding shall be designed to withstand mechanical and thermal stresses due to dead short circuit on its terminals and for 1/3rd of the MVA capacity of the transformer although the cooling for continuous thermal rating of the tertiary winding shall be for 5MVA capacity. Tertiary, if not loaded, i.e. not connected to reactor, capacitor or LT transformer etc., its terminals shall be insulated to avoid any accidental short circuiting.

If required, the surge arrester (with polymer/**porcelain** housing) shall be provided externally in proximity with bushings mounted suitably on the transformer tank. Alternatively, if required, the surge arrester may be mounted internally (as per standard practice of manufacturer), in order to limit the transfer surge within the BIL specified. Further, in case external surge arresters are required, same shall be mounted on Transformer tank.

17.10.0 Radio Interference and Noise Level

17.10.1.0 The transformers shall be designed with particular attention to the suppression of harmonic voltage, especially the third and fifth so as to minimise interference with communication circuit.

17.10.1.1 The noise level of transformer, when energised at normal voltage and frequency with fans and pumps running shall not exceed the values specified at **Annexure - A**, when measured under standard conditions.

17.11.0 Measurable Defects

17.11.1.0 The following shall constitute as Measurable Defects for the purpose of Defect Liabilities as per relevant clauses of GCC / SCC of the bidding document:

a) Repair, inside the Transformer and OLTC (including oil migration) either at site or at factory is carried out after commissioning.
b) The concentration of any fault gas is more than values of condition-1 indicated in clause no 6.5 of IEEE-C57.104-2008, which are as detailed below:

H2	**CH4**	**C2H2**	**C2H4**	**C2H6**	**CO**	**CO2**	**TDCG**
100	**120**	**1**	**50**	**65**	**350**	**2500**	**720**

c) The winding tan delta goes beyond 0.005 or increase more than 0.001 within a year w.r.t. pre-commissioning values. No temperature correction factor shall be applicable for tan delta.

d) The moisture content goes above 12 ppm at any temperature during operation including full load.

17.12.0 Design review

17.12.1.0 The transformer 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. The manufacturer will be required to demonstrate the adequate safety margin w.r.t thermal, mechanical, dielectric and electrical stress etc. shall be maintained during design, selection of raw material, manufacturing process etc. in order to achieve long life of transformer with least maintenance and to take into account the uncertainties of his design and manufacturing processes. The scope of such design review shall include but not limited to the requirement as mentioned at **Annexure – B**.

17.12.1.1 Design reviews shall be conducted by Purchaser or an appointed consultant during the procurement process for transformers; however, the entire responsibility of design shall be with the manufacturer. Purchaser may also visit the manufacturer's works to inspect design, manufacturing and test facilities at any time.

17.12.1.2 The design review will commence after placement of award and shall be finalised before commencement of manufacturing activity. These design reviews shall be carried out in detail to the specific design with reference of the transformer under the scope. It shall be conducted generally following the "CIGRE TB 529: Guidelines for conducting design reviews for power transformers".

17.12.1.3 The manufacturer shall provide all necessary information and calculations to demonstrate that the transformer meets the requirements for short circuit strength and durability. The latest recommendations of IEC or Cigre SC 12 shall be applied for short circuit withstand evaluation.

17.12.1.4 **Type test requirement & it's validity**

The offered transformer or the transformer, the design of which is similar to the offered transformer, should have been successfully type tested within **last 5 years** as on the last date of submission of bid. Manufacturer may use same or different approved make of Bushings and other accessories used in type tested or short circuit tested unit in their transformer. Central Electricity Authority's "Guidelines for the validity period of type tests conducted on major electrical equipment in power transmission system" shall be followed regarding the validity of type tests of Bushings and other accessories.

17.13.0 Construction Details

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

17.13.1.1 Tank

17.13.1.1.1 Tank shall be fabricated from tested quality low carbon steel of adequate thickness. Unless otherwise approved, metal plate, bar and sections for fabrication shall comply with BS-4360 / IS 2062.

17.13.1.1.2 All seams and joints which are not required to be opened at site, shall be factory welded, and wherever possible they shall be double welded. Welding shall conform to BS-5135/IS 9595. After fabrication 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/IS 10801.

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

17.13.1.1.3 The tank shall be of proven design either bell type with bolted /welded joint or conventional type with welded / bolted top cover. Bell type tank shall be provided with joint at about 500 mm above the bottom of the tank. The welded joint 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 at the joint.

17.13.1.1.4 Tank shall be provided with:

a. Lifting lugs: Four symmetrically placed lifting lugs shall be provided so that it will be possible to lift the complete transformer when filled with oil without structural damage to any part of the transformer. The factor of safety at any one point shall not be less than 2.

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 at least half of the total mass of the transformer filled with oil allowing in addition to maximum possible misalignment of the jacking force to the centre of the working surface.

c. Suitable haulage holes shall be provided.

d. 04 nos. of Gate valves for UHF sensors for PD Measurements (applicable for 400kV Transformer only) at various locations. Location of valves shall be finalized during design review.

e. Suitable provisions of pockets for OTI, WTI & RTDs including two spare pockets.

17.13.1.1.5 The tank shall be designed in such a way that it can be mounted either on the plinth directly or on rollers, as per manufacturer's standard practice.

17.13.1.1.6 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 damage when using plates or rails and the base plate shall have following minimum thickness:

Length of tank (m)	Minimum plate thickness (mm)
Flat bases	
Over 2.5 m but less than 5m	20
Over 5 m but less than 7.5m	26
Over 7.5 m	32

17.13.1.1.7 Tank shall be capable of withstanding, without damage, severe strains that may be induced under normal operating conditions or forces encountered during lifting, jacking and pulling during shipping and handling at site or factory. Tank, tank cover and associated structure should be adequately designed to withstand, without damage or permanent deflection / deformation, the forces arising out of normal oil pressure, test pressures, vacuum, seismic conditions and short circuit forces specified.

17.13.1.1.8 Tank MS plates of thickness >12 mm should undergo Ultrasonic Test (UT) to check
lamination defect, internal impurities in line with ASTM 435 & ASTM 577.

17.13.1.1.9 All pipes connected to Transformer shall follow IS 1239.

17.13.1.2 Tank Cover

17.13.1.2.1 The tank cover shall be designed to prevent retention of 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.

17.13.1.2.2 At least two adequately sized inspection openings one at each end of the tank, shall be provided 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.

17.13.1.2.3 The tank cover shall be provided with pockets for OTI, WTI and RTDs including 2 spare pockets. The location of pockets shall be in the position where oil reaches maximum temperature. Further, it shall be possible to remove bulbs of OTI/WTI/RTD without lowering the oil in the tank. The thermometer shall be fitted with a captive screw to prevent the ingress of water.

17.13.1.2.4 Bushing turrets, covers of inspection openings, thermometer pockets etc. shall be designed to prevent ingress of water into or leakage of oil from the tank.

17.13.1.2.5 To allow for the effect of possible induced and capacitive surge current flow, the tank cover and bushing turret shall be fixed to the transformer in such a way that good electrical contact is maintained around the perimeter of the tank and turrets.

17.13.1.2.6 The transformer shall be provided with a suitable diameter pipe flange, butterfly valve, bolted blanking plate and gasket shall be fitted at the highest point of the transformer for maintaining vacuum in the tank.

17.13.1.3 Gas venting

The transformer cover and generally the internal spaces of the transformer and all pipe connections shall be designed so as to provide efficient venting of any gas in any part of the transformer to the Buchholz relay. The space created under inspection /manhole covers shall be filled with suitable material to avoid inadvertent gas pockets. The Covers shall be vented at least at both longitudinal ends. The design for gas venting shall take into accounts the slopes of the plinth (if any) on which the transformer is being mounted.

17.13.1.4 Gasket for tank & cover

All gasketed joints in contact with oil shall be designed, manufactured and assembled to ensure long-term leak and maintenance free operation. All gasketed joints unless otherwise approved shall be of the O-ring and groove type. 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 tank gaskets used shall be of NBR (Acrylonitrile butadiene Rubber generally known as NBR) and properties of all the above gaskets / O-Rings shall comply with the requirements of IS-11149 (Grade IV) Material selected shall suit temperature conditions expected to be encountered. Neoprene / cork sheets gaskets are not acceptable. The Gaskets and O-rings shall be replaced every time whenever the joints are opened.

17.13.1.6 Roller Assembly and Anti Earthquake Clamping Device

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-Phase auto transformers of 400kV class shall have four (4) rails and other voltage class transformers shall have two (2) rails.

To prevent transformer movement during earthquake, suitable clamping devices shall be provided for fixing the transformer to the foundation.

17.13.1.7 Conservator

17.10.1.7.1 Main tank conservator shall have air cell type constant oil pressure system to prevent oxidation and contamination of oil due to contact with moisture. Conservator shall be fitted with magnetic oil level gauge with potential free high and low oil level alarm contacts, prismatic oil level gauge and Conservator Protection Relay (CPR)/Air cell puncture detection relay.

Conservator Protection Relay (CPR)/Air cell puncture detection relay shall be installed to give alarm in the event of lowering of oil in the conservator due to puncture of air cell in service.

17.13.1.7.2 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 top oil temperature of 110 deg 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.

17.13.1.7.3 The conservator shall be fitted with 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 as applicable.

17.13.1.7.4 Conservator shall be positioned so as not to obstruct any electrical connection to transformer.

17.13.1.7.5 The connection of air cell to the top of the conservator is by air proof seal preventing entrance of air into the conservator. The main conservator tank shall be stencilled on its underside with the words **“Caution: Air cell fitted”.** Lettering of at least 150 mm size shall be used in such a way to ensure clear legibility from ground level when the transformer is fully installed. To prevent oil filling into the air cell, the oil filling aperture shall be clearly marked. The transformer rating and diagram plate shall bear a warning statement that the **“Main conservator is fitted with an air cell”.**

17.13.1.7.6 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 in the conservator is likely to raise up to 110 deg.C during operation. As such air cell used shall be suitable for operating continuously at this temperature.

17.13.1.7.7 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, and the recommended replacement intervals.

17.13.1.7.8 The conservator tank and piping shall be designed for complete vacuum / filling of the main tank and conservator tank. Provision must be made for equalising the pressure in the conservator tank and the air cell during vacuum / filling operations to prevent rupturing of the air cell.

17.13.1.7.9 The contractor shall furnish the leakage rates of the rubber bag/ air cell for oxygen and moisture. It is preferred that the leakage rate for oxygen from the air cell into the oil will be low enough so that the oil will not generally become saturated with oxygen. Air cells with well proven long-life characteristics shall be preferred. OLTC shall have conventional type conservator (without aircell) with magnetic oil level gauge with potential free oil level alarm contact and prismatic oil level gauge.

17.13.2.0 Piping works for conservator

17.13.2.1 Pipe work connections shall be of adequate size preferably short and direct. Only radiused elbows shall be used.

17.13.2.2 The feed pipe to the transformer tank shall enter the transformer cover plate at its highest point and shall be loaded 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 degrees. The feed pipe diameter for the main conservator shall be not less than 80 mm.

17.13.2.3 This pipe shall rise towards the oil conservator, through the Buchholz relay, at an angle of not less than 5 degrees. The feed pipe diameter for the main conservator shall be not less than 80mm.

17.13.2.4 A double flange valve of preferably 50 mm and 25 mm size shall be provided to fully drain the oil from the main tank conservator and OLTC conservator tank respectively.

17.13.2.5 Pipe work shall neither obstruct the removal of tap changers for maintenance or the opening of inspection or manhole covers.

17.13.3.0 Dehydrating Silica gel Filter Breather

17.13.3.1 Conservator of Main Tank and OLTC shall be fitted with a dehydrating **non-carcinogenic** silica gel filter breather.. 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) Passage of air is through silica gel.
b) Silicagel is isolated from atmosphere by an oil seal.

c) Moisture absorption indicated by a change in colour of the crystals.
d) Breather is mounted approximately 1200 mm above rail top level.
e) To minimise the ingress of moisture three breathers (of identical size) for 220kV and above voltage class transformer and two breathers (of identical size) for below 220kV class transformer shall be connected in series for main tank conservator. Manufacturer shall provide flexible connection pipes to be used during replacement of any silica gel breather.
f) To minimise the ingress of moisture, two in series of identical size shall be connected to OLTC Conservator. Contractor shall provide flexible connection pipes to be used during replacement of any silicagel breather.

17.13.3.2 **Thermosyphon Filter:**

To extract the harmful constituents like water, acids etc. from oil, Thermosyphon filter of cylindrical shape with perforated steel trays filled with absorbents such as active alumina should be provided.

The filter assembly shall be mounted on the transformer as well as ground supported and connected with pipes and shut off valves. Suitable instructions required to be followed for commissioning, dismantlement and maintenance of filter arrangement, re-generation and storage of the absorbent etc. must be included in the instrumentation manual. A detailed drawing showing internal arrangement shall be submitted.

The oil & absorbent capacity required in the thermo-syphon filter is as under.

i) Quantity of oil	-	1.0% of total oil by weight
ii) Quantity of absorbent	-	0.2% to 0.25% of total oil by weight

17.13.4.0 Pressure Relief Device

17.13.4.1 One PRD of 150 mm Diameter is required for every 30000 Litres of oil. However, at least two numbers PRDs shall be provided. Its mounting should be either in vertical or horizontal orientation, preferably close to bushing turret or cover. PRD operating pressure selected shall be verified during design review. PRD shall be provided with special shroud to direct the hot oil in case of fault condition. It shall be provided with an outlet pipe which shall be taken right up to the soak pit of the transformer. The size (Diameter) of shroud shall be such that it should not restrict rapid release of any pressure that may be generated in the tank, which may result in damage to equipment. Oil shroud should be kept away from control cubicle and clear of any operating position to avoid injury to personnel in the event of PRD operation. The device shall maintain its oil tightness under static oil pressure equal to the static operating head of oil plus 20 kPa.

Pressure Relief Device:
It shall be capable of withstanding full internal vacuum at mean sea level. It shall be mounted directly on the tank. Suitable canopy shall be provided to prevent ingress of rain water in **PRV and its terminal box**. One set of potential free contacts (1NO+1NC) (with plug & socket type arrangement) per device shall be provided for tripping.

a) Air pressure test
b) Liquid pressure test
c) Leakage test

d) Contact operation test
e) Dielectric test on contact terminals

17.13.5.0 Sudden Pressure Relay

17.13.5.1 **Sudden Pressure relay:**
One number of Sudden Pressure relay with alarm/trip contacts (Terminal connection plug & socket type arrangement) shall be provided on tank of transformer. Operating features and size shall be reviewed during design review. Suitable canopy shall be provided to prevent ingress of rain water in SPR and **its terminal box**. Pressurized water ingress test for Terminal Box (routine tests) shall be conducted on Sudden Pressure Relay.

17.13.6.0 Buchholz Relay
17.13.6.1 Two numbers double float, reed type Buchholz relay shall be provided in series of the connecting pipe between the oil conservator and the Transformer tank with minimum distance of five times pipe diameters between them. Any gas evolved in the Transformer shall be collected 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 tube shall be connected from the gas collector to a valve located about 1200 mm above ground level to facilitate sampling while the Transformer in service. Suitable canopy shall be provided to prevent ingress of rain water. Each device shall be provided with two potential free contacts **(Plug & socket type arrangement),** one for alarm / trip on gas accumulation and the other for tripping on sudden rise of pressure.

17.13.6.2 The Buchholz relay shall not operate during starting/ stopping of the transformer oil circulation under any oil temperature conditions. The pipe or relay aperture baffles shall not be used to decrease the sensitivity of the relay. The relay shall not mal-operate for through fault conditions or be influenced by the magnetic fields around the transformer during the external fault conditions. Pressurised water ingress test for Terminal Box (routine tests) shall be conducted on Buchholz relay.

17.13.7.0 Oil Surge Relay
Reed type Oil Surge Relay shall be provided individually to each tap changer diverter switches and one common OSR at OLTC conservator tank. Valves of required size are to be put before and after of each OSR. For 3-phase OLTC, there shall be two numbers OSR. It is preferable that each oil surge relays have independent indicators. OSR shall have two trip contacts.

17.13.8.0 Oil Temperature Indicator (OTI)
All transformers shall be provided with a dial type thermometer of around 150 mm diameter for top oil temperature indication with angular sweep of 270°. It shall have adjustable, potential free alarm and trip contacts besides that required for control of cooling equipment if any. A temperature sensing element suitably located in a pocket on top oil shall be provided. This shall be connected to the OTI instrument by means of flexible capillary tubing with stainless-steel armoured. Temperature indicator dials shall have linear gradations to clearly read at least every 2 deg C. Range of temperature should be 0- 150°C with accuracy of ±1.5% (or better) of full-scale deflection. The setting of alarm and tripping contacts shall be adjustable at site. Adjustable range shall be 20-90% of full-scale range. Heavy duty micro switch of 5A at 240V AC shall be used. The instruments case should be weather proof and having epoxy coating at all sides. Instruments should meet ingress protection class of IP55 as per IS 13947/IEC60529. The instruments should be capable of withstanding line to body high voltage of 2.5kV AC rms, 50Hz for 1 minute.

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

Temperature transducer with Pt100 sensor (As per ANNEXURE- J)

RTD shall be provided with PT100 temperature sensor having nominal resistance of 100 ohms at zero degree centigrade. The PT100 temperature sensor shall have three wire ungrounded system. The calibration shall be as per IEC 60751-2 or equivalent. The PT100 sensor may be placed in the pocket containing temperature sensing element. RTD shall include image coil for OTI system and shall provide dual output 4-20mA for SCADA system. The transducer shall be installed in the Individual Marshalling Box. Any special cable required for shielding purpose, for connection between PT100 temperature sensor and transducer, shall be in

the scope of Contractor. 4-20mA signal shall be wired to Digital RTCC panel / BCU for further transfer data to SCADA through IEC 61850 compliant communications.

17.13.9.0 Winding Temperature Indicator (WTI)

17.13.9.1 All Transformers shall be provided with a device for measuring the hot spot temperature of each winding (HV, IV and LV) with dial type thermometer of 150 mm diameter for winding temperature indication with angular sweep of 270° and shall have adjustable potential free alarm and trip contacts besides that required for control of cooling equipment if any. The setting of alarm and tripping contacts shall be adjustable at site. A temperature sensing bulb located in a thermometer pocket on tank cover should be provided to sense top oil. This shall be connected to the WTI instrument by means of flexible capillary tubing with stainless-steel armoured. WTI shall have image coil and auxiliary CTs, if required to match the image coil, shall be mounted in the Marshalling Box / cooler control cabinet. Temperature indicator dials shall have linear gradations to clearly read at least every 2°C. Range of temperature should be 0- 150°C with accuracy of ±1.5% (or better) of full-scale deflection. Adjustable range shall be 20-90% of full-scale range. Heavy duty micro switch of 5A at 240V AC shall be used. The instruments case should be weather proof and having epoxy coating at all sides. Instruments should meet ingress protection class of IP55 as per IS 13947 /IEC60529. The instruments should be capable of withstanding line to body high voltage of 2.5kV AC rms, 50Hz for 1 minute.

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

Temperature transducer with Pt100 sensor for each winding (As per ANNEXURE- J)

RTD shall be provided with Pt100 temperature sensor having nominal resistance of 100 ohms at zero degree centigrade. The Pt100 temperature sensor shall have three wire ungrounded system. The calibration shall be as per IEC 60751-2 or equivalent. The Pt100 sensor may be placed in the pocket containing temperature sensing element. RTD shall include image coil, Auxiliary CTs, if required to match the image coil, for WTI system and shall provide dual output 4-20mA for remote WTI and SCADA system individually. The transducer, Auxiliary CT shall be installed in the Individual Marshalling Box. Any special cable required for shielding purpose, for connection between Pt100 temperature sensor and transducer, shall be in the scope of Contractor. 4-20mA signal shall be wired to Digital RTCC / BCU panel for further transfer data to SCADA through IEC 61850 compliant communications.

The temperature indicators (OTI & WTI) shall be so mounted that the dials are about 1200 mm from ground level. Glazed door of suitable size shall be provided for convenience of reading.

17.13.10.3 Optical sensors & temperature measuring unit

17.10.10.3.1 Optical temperature sensors shall be fitted on each Transformer unit. 16 number probes for 3-ph unit shall be provided. The optical sensors measuring system shall be of direct measurement non-calibrating type. All the sensors shall be brought out to separate optical sensor box or in Individual Marshalling Box mounted on transformer tank to facilitate measurement of temperature during service life on each unit.

17.13.10.3.2 In order to facilitate measurement of temperature from the optical sensors, temperature measuring unit/system having at least 16 channels shall be mounted inside the separate optical sensor box or Transformer Marshalling Box for each transformer unit**.** The measuring unit shall be capable to retain temperature data for at least 30 days with facility to download these data.

17.13.10.3.3 Temperature measuring unit/system shall be suitable for satisfactory operation with ambient conditions and IEC 61850 compliant to interface with Employer's SCADA system through FO port.

17.13.10.3.4 Location of optical temperature sensors inside the transformer shall be decided during design review.

17.13.10.3.5 The installation and commissioning at site shall be done under the supervision of OEM representative or OEM certified representative.

17.13.10.4 Earthing Terminals

17.13.10.4.1 Two (2) earthing pads (each complete with two (2) nos. holes, M16 bolts, plain and spring washers) suitable for connection to 75 x 12 mm galvanised steel grounding flat shall be provided each at position close to earth of the two (2) diagonally opposite bottom corners of the tank.

17.13.10.4.2 Two earthing terminals suitable for connection to 75 x 12 mm galvanised steel flat shall also be provided on each cooler, individual/common marshalling box and any other equipment mounted separately. For the tank-mounted equipment like online drying/ Online DGA/ Optical Sensor Box etc. double earthing shall be provided through the tank for which provision shall be made through tank and connected through two flexible insulated copper links.

17.13.10.4.3 Equipotential flexible copper link of suitable size at least 4 Nos. for Tank mounted turret with tank and tank with cover and or Bell shall be provided. For other components like - pipes, conservator support etc. connected to tank shall also be provided with equipotential flexible copper link.

17.13.10.4.4 Earthing terminal: Neutral shall have provision for connection to ground by a brass/tinned copper grounding bar supported from the tank by using porcelain insulator. The end of the tinned/brass copper bar shall be brought to the bottom of the tank at a convenient point for making bolted connection to 75 X 12 mm GS flat connected to station grounding mat through two (2) separate earthing pits. The other end of the tinned/brass copper bar shall be connected to the neutral bushing through flexible conductor/jumper.

17.13.9.0 Core

17.13.9.1 The magnetic circuit shall be core type. Each limb shall be joined with top and bottom yokes. The laminations shall be made from high grade non-ageing cold rolled grain oriented (CRGO) silicon alloy of **HI -B** grade steel (as per **BIS / IEC**). Indian transformer manufacturers shall use core material as per above specification with BIS certification. Only those bidders who directly imported **CRGO** either from the manufacturer or through their accredited marketing organization of repute (and not through any agent) shall be considered. **In support of this requirement the bidder shall submit an undertaking in specified format (Annexure C) in the form of affidavit on Rs.100/- stamp paper, duly notarized.**

Laminations of one particular thickness i.e., 0.23mm or 0.27mm or better (quoted grade and type) shall be used. Laminations of different grade(s) and different thickness(s) are not allowed to be used in any manner or under any circumstance.

17.13.9.2 The CRGO shall be cut at Mill's authorized Processing unit only.

17.13.9.3 The temperature of any part of the core or its support structure in contact with oil shall not exceed 120 deg C under normal operating condition and 130 deg C under 10% over voltage and maximum ambient air temperature conditions of 50 deg C. Adequate temperature margin shall be provided to maintain the long-life expectancy for this material.

The hot spot temperature and surface temperatures in the core shall be calculated for over voltage conditions specified in the document and it shall not exceed 125 deg C and 120 deg C respectively.

17.13.9.4 Core and winding shall be capable of withstanding the shock during transport, installation and service and adequate provision shall be made to prevent movement of core and winding with respect to tank during these conditions.

17.13.9.5 All steel sections used for supporting the core shall be thoroughly sand / shot blasted after cutting, drilling and welding.

17.13.9.6 Each core lamination shall be insulated with a material that will not deteriorate due to pressure and hot oil.

17.13.9.7 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.

17.13.9.8 Adequate lifting lugs will be provided to enable the core and windings to be lifted.

17.13.9.9 Single point core earthing should be ensured to avoid circulating current. Core earth should be brought separately on the top of the tank to facilitate testing after installation on all transformers. The removable links shall have adequate section to carry ground fault current. Separate identification name plate/labels shall be provided for the 'Core' and 'Core clamp'. Cross section of Core earthing connection shall be of minimum size 80 sq.mm copper with exception of the connections inserted between laminations which may be reduced to a cross-sectional area of 20 sq. mm tinned copper where they are clamped between the laminations.

17.13.9.10 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.

17.13.9.11 The insulation of core to tank, core to yoke clamp (frame) and yoke clamp (frame) to tank shall be able to withstand a voltage of 2.5 kV (DC) for 1 minute. Insulation resistance shall be minimum 500MΩ for all cases mentioned above.

17.13.9.12 The maximum flux density in any part of the core and yoke at the rated MVA, voltage & frequency shall be such that less than 10% continuous over voltage condition does not exceed 1.9 Tesla.

17.13.9.13 For consideration of over fluxing, the transformer shall be suitable for continuous operation for values of over fluxing at (i) 110% (ii) one minute for 125% and (iii) 5 seconds for 140% of rated voltage.

17.13.9.14 The Transformer shall be of **BOLTLESS** core design. The Bidders will furnish documentary evidence with proof of their experience and performance in such type of design.

17.13.9.15 When bell type construction is offered, suitable projecting guides shall be provided on core assembly to facilitate removal of tank. The supporting framework of core shall be so designed so as to avoid presence of pockets, which would prevent complete emptying of the tank through drain valve or cause trapping of air during oil filling.

17.13.9.16 Successful Bidder shall furnish calculation towards maximum peak value of magnetizing in- rush current and shall justify that the transformer will not trip due to this during initial charging and subsequent charging.

17.13.9.17 Oil ducts shall be provided where necessary to ensure adequate cooling. The welding structure and major insulation shall not obstruct the free flow of oil through such ducts.

17.13.9.18 The prime core materials are only to be used. Bidder's should furnish following document as applicable as a proof towards use of prime Core material to be submitted before the stage inspection:

(a) Invoice of supplier
(b) Mill's test certificate

(c) Packing List
(d) Bill of lading
(e) Bill of entry certificate by Custom.
(f) Description of material, electrical analysis, physical inspection, certificate for surface defects, thickness and width of the materials.
(g) Place of cutting of core materials

All parts of the cores shall be of robust design capable of withstanding any shocks to which they may be subjected during lifting, transport, installation and service.

17.13.9.19 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.

17.14.0 Windings

17.14.1.0 General

- The manufacturer shall ensure that windings of all transformers are made in clean, dust proof (Cleanroom class ISO 9 or better as per ISO 14644-1), humidity-controlled environment with positive atmospheric pressure. The conductors shall be of electrolytic grade copper free from scales and burrs. Oxygen content shall be as per IS 12444.
- Epoxy bonded Continuously Transposed Conductor (CTC) shall be used in main winding for rated current of 400 A or more.
- The insulation of transformer windings and connections shall be free from insulating compounds which are liable to soften, ooze out, shrink or collapse and shall be non-catalytic and chemically inactive in transformer oil during service.

- 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.

- The coils would be made up, shaped and braced to provide for expansion and contraction due to temperature changes.

- The conductor shall be transposed at sufficient intervals in order to minimize eddy currents and to equalise the distribution of currents and temperature along the winding.

- The windings shall be designed to withstand the dielectric tests specified. The type of winding used shall be of time tested. An analysis shall be made of the transient voltage distribution in the windings, and the clearances used to withstand the various voltages. Margins shall be used in recognition of manufacturing tolerances and considering the fact that the system will not always be in the new factory condition.

- The barrier insulation including spacers shall be made from high density precompressed pressboard (1.15 gm/cc minimum for load bearing and 0.95 gm/cc minimum for non-load bearing) to minimize dimensional changes. Kraft insulating paper used on conductor should have density of >0.75 g/cc.

- The conductor insulation shall be made from high-density (at least 0.75 gm/cc) paper having high mechanical strength. The characteristics for the paper will be reviewed at the time of design review.

- Wherever required, electrostatic shield, made from material that will withstand the mechanical forces, will be used to shield the high voltage windings from the magnetic circuit.

- All winding insulation shall be processed to ensure that there will be no detrimental shrinkage after assembly. All windings shall be pre-sized before being clamped.

- Windings shall be provided with clamping arrangements which will distribute the clamping forces evenly over the ends of the winding. Either brazing/crimping type of connections are permitted for joints. It shall be time proven and safely withstand the cumulative effect of stress which may occur during handling, transportation, installation and service including line to line and line to ground faults /Short circuits. Manufacturer shall have system which allows only qualified personnel to make brazing or crimping joints.
- Winding paper moisture shall be less than 0.5%.
- **In the case of ICTs with tertiary**, the insulation of LV (Tertiary) winding shall be adequate to withstand surge voltages appearing across them as a result of transfer due to impulse striking on HV or IV terminals. **The transformer shall be suitably designed so that the surges transferred to tertiary winding do not exceed the permissible limits** without the use of any external means such as surge capacitors etc. under any condition. The tenderer shall also state whether the transferred surges could be restricted to 170 KVP without the use of any external means. **The current density of the conductor used for tertiary winding shall not exceed the current density specified for the main winding**/conductor.

- The stacks of windings shall receive adequate shrinkage treatment before and after final assembly. Adjustable devices, if necessary, shall be provided for taking up possible shrinkage of coils if any, in service. The provision made in this respect shall be clearly brought out in the Bid.

- **The conductors shall be transposed at suitable intervals in order to minimize eddy current** and to equalize the distribution of current and temperature along the windings.

- The transformer manufacturer should have in house availability of vapour phase Drying (VPD) plant for proper drying of the insulation. In case VPD facility is not available, the bidder will prove that the method of drying adopted by them is equivalent or better than VPD in terms of level of dryness and other benefits of VPD.

17.14.1.1 Bracing of Windings

- The windings and connections of all transformers shall be braced to withstand socks, which may occur during transport or due to switching and other transient conditions during service.

- The winding shall be clamped securely in place, so that they will not be displaced or deformed during short circuit. The assembled core and winding shall vacuum dried and suitably impregnated before removing from the treating tank.

- Coil clamping rings, if provided shall be of steel.

- If the transpose winding is built up of section of disc coils, separated by spacers, the clamping arrangements shall be such that equal pressures are applied to all columns of spacers. All such spacers shall be securely located, shall be of suitable material and shall receive adequate shrinkage treatment before assembly.

- Winding shall be subjected to a shrinking and seasoning process, so that no further shrinkage occurs during service. Adjustable devices shall be provided for taking up possible shrinkage in service.

- Winding shall not contain sharp bends which might damage the insulation or produce high dielectric stresses. No strip conductor wound on edge shall have width exceeding six times the thickness.

- Varnish application on coil windings may be given only for mechanical protection and not for improvement in dielectric properties. In no case varnish or other adhesive, be used which will seal the coil and prevent evacuation of air and moisture and impregnation by oil.

- Winding and connections shall be braced to withstand shocks during transport or short circuit.

- Permanent current carrying joints in the windings and leads shall be welded or brazed. Clamping bolts for current carrying parts inside oil shall be made of oil resistant material which shall not be affected by acidity in the oil steel bolts, if used, shall be suitably treated.

- Terminals of all windings shall be brought out of the tank through bushings for external connections.

- The winding shall be so designed that all coil assemblies of identical voltage ratings shall be interchangeable and field repairs to the winding can be made readily without special equipment. The coils shall have high dielectric strength.

- Coils shall be made of continuous smooth high-grade electrolytic copper conductor, shaped and braced to provide for expansion and contraction due to temperature changes.

- Adequate barriers shall be provided between coils and core and between high and low voltage coil. End turns shall have additional protection against abnormal line disturbances. The TM is to submit the process at the time of the bid.

- Tappings shall not be brought out from inside the coil or from intermediate turns and shall be so arranged as to preserve as far as possible magnetic balance of the transformer at all voltage ratios.

- Magnitude of impulse surges transferred from HV to LV windings by induction and capacitance coupling shall be limited to B.I.L. of LV winding.

17.14.1.2 Current carrying connections

The mating faces of bolted connections shall be appropriately finished and prepared for achieving good long lasting, electrically stable and effective contacts. All lugs for crimping shall be of the correct size for the conductors. Connections shall be carefully designed to limit hot spots due to circulating eddy currents.

17.14.1.3 Winding terminations into bushings

- Winding termination interfaces with bushings shall be designed to allow for repeatable and safe connection under site conditions to ensure the integrity of the transformer in service.

- The winding end termination, insulation system and transport fixings shall be so designed that the integrity of the insulation system generally remains intact during repeated work in this area.

- Allowances shall be made on the winding ends for accommodating tolerances on the axial dimensions of the set of bushings and also for the fact that bushings may have to be rotated to get oil level inspection gauges to face in a direction for ease of inspection from ground level.

- In particular, rotation or straining of insulated connections shall be avoided during the fastening of conductor pads (or other methods) on the winding ends onto the termination surfaces of the bushing.

- Suitable inspection and access facilities into the tank in the bushing oil-end area shall be provided to minimize the possibility of creating faults during the installation of bushings.

17.15.0 Transformer Loading

- The limits of temperature rise are given in general technical parameters.

- The transformer shall be capable of remaining in operation at full load without the measured winding hot spot temperature exceeding 150°C for:

    - 10 minutes with complete (i.e.,100%) failure of cooler system.
    - 20 minutes with 50% of cooler system in service.

- The permissible temperature of the top oil shall refer to the specific loading combination for which the total losses are the highest. Individual permissible winding temperature rise shall be considered relative to the specified loading combination which is the most severe for the particular winding under consideration.

17.16.0 Terminal Arrangement

Specific requirement of bushings and their ratings etc. are as per general technical parameters.

17.17.0 Bushings

- The electrical and mechanical characteristics of bushings shall be in accordance with IS: 2099 and IS: 3347 (Part-III/Section-I). Dimensions and requirements of condenser bushings shall be in accordance with IS 12676, 1989.
- Bushings shall be robust and designed for adequate cantilever strength **(Heavy Load of Level-II as per latest revision of IEC 60137)** to meet the requirement of seismic condition, substation layout and movement along with the spare. Transformer with bushing erected and provided with proper support from one foundation to another foundation within the substation area. The electrical and mechanical characteristics of bushings shall be in accordance with IEC: 60137/DIN 42530. All details of the bushing shall be submitted for approval and design review. **Transformer HT and LT Bushings shall be designed to withstand the seismic effect of 0.36g..**

- 420kV, 245kV, 145kV and **72.5kV** Bushings shall be either of the following type:

a) RIP (Resin Impregnated paper) condenser type with composite polymer insulator (housing) b) or RIS (Resin Impregnated Synthetic) condenser type with composite polymer insulator (housing). However, OIP (Oil impregnated Paper) with porcelain / composite polymer housing type is also acceptable for **72.5kV**
Bushings..

36kV and below voltage class bushing shall be solid or oil communicating type with porcelain housing.

No arcing horns shall be provided on any bushing.

(c) Condenser type bushings shall be provided with-

i) Oil level gauge.
ii) Oil filling plug and drain valve if not hermetically sealed;
iii) Tap for capacitance/tan delta measurement.

(d) RIP/RIS type bushing shall be provided with tap for capacitance and tan delta test. Test
taps relying on pressure contacts against the outer earth layer of the bushing is not acceptable.

(e) Where turret type current transformers are specified, the bushings shall be removable without disturbing the current transformers.

(f) Bushing for voltage of 52 kV and above shall be RIP/RIS bushing with composite polymer insulator. 36 kV and below voltage class bushing shall be solid porcelain or oil communicating type.

(g) No arcing horns shall be provided on the bushings. Bushing shall be as per technical particulars furnished. Bushings of identical rating shall be interchangeable to optimise the requirement of spares.

(h) RIP/RIS Bushing shall be specially packed to avoid any damage during transit and suitable for long storage, with non-returnable packing wooden boxes with hinged type cover. Without any gap between wooden planks. Packing Box opening cover with nails/screws type packing arrangement shall not be acceptable. Bushing oil end portion shall be fitted with metal housing with positive dry air pressure and a suitable pressure monitoring device shall be fitted on the metal housing during storage to avoid direct contact with moisture with epoxy. Alternatively, oil filled metal housing with suitable arrangement for taking care oil expansion due to temperature variations shall also be acceptable. Manufacturer shall submit drawing/ documents of packing for approval during detail engineering. Detail method for storage of bushing including accessories shall be brought out in the instruction manual.

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

(j) Tan delta measurement at variable frequency (in the range of 20 Hz to 350 Hz) shall be carried out on each condenser type bushing (OIP & RIP) at Transformer manufacturing works as routine test before despatch and the result shall be compared at site during commissioning to verify the healthiness of the bushing.

(k) Tan δ value of RIP / RIS condenser bushing shall be 0.005 (max.) in the temperature range of 20°C to 90°C. The measured Tan δ value at site of in-service bushing should not exceed by 0.001 w.r.t. factory results (measured at approx. similar temperature conditions) during warrantee period. Tan delta value of OIP Bushing shall be 0.004 (Max) measured at ambient temperature. The measured Tan δ value at site of in-service bushing should not exceed by 0.001 w.r.t. factory results during warrantee period.

(l) Special precaution shall be taken to eliminate moisture from paper insulation during manufacture, assembly, transport and erection.

(m) Bushing turrets shall be provided with vent pipes which shall be connected to route any gas collection through the Buchholz relay.

(n) To accommodate the bushing current transformers, space provided on the various voltage class bushings shall be as under:

420kV: 400 mm *

245kV: 300 mm *
: 600 mm **

145kV: 100 mm *
: 300 mm **
: 600 mm ***

Note:
*** = for one BCT**
**** = For two BCTs**
***** = For three BCTs**

17.17.1.0 Terminal Connectors

- Bushing terminals shall be provided with terminal connectors of approved type and size for connection to external parts. Terminal connectors should have been successfully type tested strictly as per IS: 5561.

- **All connections with ACSR/AAAC conductors shall be Nut and bolt type.**
- Connectors shall be of **electrolytic grade copper forged and silver plated/tinned.** No part of a clamp shall be less than 10 mm thick.

- Non-magnetic stainless-steel nuts, bolts and plain washers shall be used. Nuts and bolts shall have hexagonal head with threads as per IS and shall be fully threaded type. Instead of spring washers, check/lock nuts shall be provided.

- The connectors shall be designed for minimum 120% of the maximum current carrying capacity of the ACSR conductor and the temperature rise under these conditions shall not be more than 50% of that of the main conductor.

17.17.2.0 Bushing current transformers

- Current transformers shall comply with IS: 2705.

- It shall be possible to remove turret mounted CTs from the transformer tank without removing the tank cover. Necessary precaution shall be taken to minimize the eddy currents and local heat generated in the turret.

- All secondary leads shall be brought to a terminal box near each bushing. These terminals shall be wired up to the Cooler Control Cabinet using separate cables for each core/phase.

- Bushing CT parameters indicated in the specification are tentative and liable to change within reasonable limits. The Bidder shall obtain the Purchaser's approval before proceeding with design of Bushing CTs.

17.17.3.0 Terminal Marking

The terminal marking and their physical position shall be in accordance with IS: 2026 unless otherwise specified**.**

17.17.4.0 Neutral Formation and Earthing Arrangement

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.

17.18.0 Cooling Equipment and its Control

17.18.1.0 Cooling Equipment for Radiator Bank

- The cooler shall be designed using radiator banks or tank mounted radiators. Design of Cooling system shall satisfy the performance requirements.

- In case of separately mounted radiator bank arrangement, **radiator bank shall generally be placed on left side of the tank while watching from HV side of the transformer**. However, the main tank shall have provision such that cooler banks can be placed on either side of the main tank by simple reconnection without the need of any extra member/pipe maintaining the electrical clearances..

- The radiator shall be of sheet steel in accordance with IS 513 and minimum thickness 1.2 mm Each radiator bank shall be provided with the following accessories:

    - Cooling Fans, Oil Pumps, Oil Flow Indicator (as applicable)
    - Top and bottom shut off valve
    - Drain Valve and sampling valve
    - Top and bottom oil filling valves
    - Air release plug
    - Two grounding terminals for termination of two (2) Nos. 75x12 mm galvanised Steel flats.
    - Thermometer pockets with captive screw caps at cooler inlet and outlet.
    - Lifting lugs: Each radiator bank shall be detachable and shall be provided with flanged inlet and outlet branches. Expansion joint shall be provided on top and bottom cooler pipe connection.

- If radiators are directly mounted on tank, sufficient number of thermometer pockets fitted with captive screw cap on the inlet and outlet of tank side pipe of radiators shall be provided to record temperature during temperature rise test.

- One number standby fan shall be provided with each radiator bank.

- Cooling fans shall not be directly mounted on radiator. It may cause undue vibration. These shall be located so as to prevent ingress of rain water. Each fan shall be suitably protected by galvanised wire guard. The exhaust air flow from cooling fan shall not be directed towards the main tank in any case.

- Two (2), 100% centrifugal or axial in line oil pumps, if applicable, (out of which one pump shall be standby) shall be provided with each radiator bank. Measures shall be taken to prevent mal-operation of

Buchholz relay when all oil pumps are simultaneously put into service. The pump shall be so designed that upon failure of power supply to the pump motor, the pump impeller will not limit the natural circulation of oil.

- An oil flow indicator shall be provided for the confirmation of the oil pump operating in a normal state. An indication in the flow indicator and potential free contacts for remote alarm shall be provided.

- Valves shall be provided across the pump and oil flow indicator to avoid oil drain and long outage during maintenance / replacement of pump and oil flow indicator.

- Cooling fans and oil pump motors shall be suitable for operation from 415 volts, three phase 50 Hz power supply and shall be of premium efficiency class IE3 conforming to IS: 12615. Each cooling fan and oil pump 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 as per IS/IEC 60034-5.
- The cooler pipes, support structure including radiators and its accessories shall be hot dip galvanised or corrosion resistant paint should be applied to external surface of it.

- Air release device and oil plug shall be provided on oil pipe connections. Drain valves shall be provided in order that each section of pipe work can be drained independently.

17.18.1.1 Cooling Equipment Control for Radiator banks

- Automatic operation control of fans/pumps 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 over entire cooling option. The setting shall be such that hunting i.e. frequent start-up operations for small temperature differential do not occur.

- Suitable manual control facility for cooler fans and oil pumps shall be provided. Selector switches and push buttons shall also be provided in the cooler control cabinet to disconnect the automatic control and start/stop the fans and pump manually. The changeover to standby oil pump in case of failure of service oil pump shall be automatic.

- In addition to the traditional starting of fan and pump by winding & oil temperature, the starting of forced cooling shall be done if the load exceeds a current setting of 0.6 p.u. for 5 seconds. Furthermore, a one-week timer is required to check the healthiness of the cooling system on a routine basis for one hour at a time.

- Following lamp indications shall be provided in cooler control cabinet:
    - Cooler Supply failure (main)
    - Cooler supply changeover
    - Cooler Supply failure (standby)
    - Control Supply failure
    - Cooling fan failure for each bank
    - Cooling pump failure for each pump
    - 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 and for single ph. Unit connection shall be extended further to CMB.

- The cooler control cabinet / Individual Marshalling box shall have all necessary devices meant for cooler control and local temperature indicators. All the contacts of various protective devices mounted on the transformer and all the secondary terminals of the bushing CTs shall also be wired upto the terminal board in the cooler control cabinet/Individual Marshalling box. All the CT secondary terminals in the cooler control cabinet shall have provision for shorting to avoid CT open circuit while it is not in use.

- All the necessary terminations for remote connection to Purchaser's panel shall be wired upto the Marshalling Box.

- The Contractor shall derive AC power for Cooler Control Circuitry from the AC feeder. 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. Details of station auxiliary power supply are mentioned in CLAUSE 7.1.2 OF CHAPTER 7.

17.18.1.2 Unit cooler arrangement for transformer (if applicable)

The cooler shall be designed using Unit Cooler arrangement with capacity as specified in Annexure-A. Design of cooling system shall satisfy the performance requirements.
Each Unit Cooler shall have its own cooling fans, oil pumps, oil flow indicator, shut off valves at the top and bottom of at least 80 mm 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.
An oil flow indicator shall be provided for the confirmation of the oil pump operating in a normal state. An indication shall be provided in the flow indicator to indicate reverse flow of oil/loss of oil flow.
Valves shall be provided across the pump and oil flow indicator to avoid oil drain and long outage during maintenance / replacement of pump and oil flow indicator.
Cooling fans and oil pump motors shall be suitable for operation from 415 volts, three phase 50 Hz power supply and shall conform to IS: 325/IEC34. Each cooling fan and oil pump 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 as per IS: 4691/IEC: 34-5
The cooler, pipes, support structure and its accessories shall be hot dip galvanised or corrosion resistant paint should be applied to external surface of it.
Expansion joint shall be provided on top and bottom cooler pipe connections as per requirement.
Air release device and oil plug shall be provided on oil pipe connections. Drain valves shall be provided in order that each section of pipe work can be drained independently.

17.18.1.2.1 Cooling Equipment Control (OFAF or ODAF) for Unit Coolers (if applicable)

i) Suitable manual control facility for unit cooler shall be provided.
ii) The changeover to standby unit cooler bank oil pump in case of failure of any service unit cooler shall be automatic.
iii) Selector switches and push buttons shall also be provided in the cooler control cabinet to disconnect the automatic control and start/stop the unit cooler manually.
iv) Cooler fans & oil pumps of all unit coolers (except standby cooler) shall operate continuously. The starting of unit cooler shall be done as soon the Circuit Breaker of HV/IV/LV (as applicable) side is switched on.
v) Once started the cooling shall remain in operation as long as the transformer is in service. When the transformer is switched off the cooling shall continue to run for a further duration of 30 minutes. This timer shall be at least adjustable from 15 to 60 minutes. Further, a one-week timer is required to check the healthiness of the complete cooling system on a routine basis for one hour at a time. Spurious operation should however be avoided by appropriate settings. All settings shall be adjustable
vi) Adequate warning/ safety labels are required to indicate that the fans may start at any time.
vii) If any one group(s) is out of service and isolated, this shall not affect the automatic starting of the other unit cooler.

viii) Following lamp indications shall be provided in cooler control cabinet:
- Cooler Supply failure (main)
- Cooler supply changeover
- Cooler Supply failure (standby)
- Control Supply failure
- Cooler unit failure for each unit cooler
- No oil flow/reverse oil flow for pumps
- Thermal overload trip for each fan / pump

One potential free initiating contact for all the above conditions shall be wired independently to the terminal blocks of cooler control cabinet and for single ph. unit connection shall be extended further to CMB.

17.19.0 Paint system and procedures

The typical painting details for transformer main tank, pipes, conservator tank, radiator, control cabinet/ marshalling box / oil storage tank etc. shall be as given in **Annexure – D**. The proposed paint system shall generally be similar or better than this. The quality of paint should be such that its colour does not fade during drying process and shall be able to withstand temperature up to 120 deg C. The detailed painting procedure shall be finalized during award of the contract.

17.20.0 Insulating Oil

a) The required transformer oil shall be in the scope of transformer manufacturer.
b) The supplier shall dispatch the transformer filled with Nitrogen. The Bidder shall take care of the weight limitation on transport and handling facility at site. Necessary arrangement shall be ensured by the supplier to take care of pressure drop of nitrogen during transit and storage till completion of oil filling during erection. A gas pressure-testing valve with necessary pressure gauge and adapter valve shall be provided.
c) The quality of the oil supplied with transformer shall conform to the oil parameters specified in this clause.
d) No inhibitors shall be used in the oil.
e) The oil samples will be drawn as follows:
   i) Prior to filling
   ii) Before and after heat run test
   iii) Before energizing

   All tests as per IEC: 60296 shall be conducted on all samples.
f) The insulating oil shall be subjected to testing in the oil manufacturer's works, before supply, in the presence of the representative of AEGCL and the representative of the transformer manufacturer.
g) Sufficient quantity of oil necessary for first filling of all tanks, coolers and radiators at the proper level along with 10% extra oil by weight for topping up shall be supplied in non-returnable containers suitable for outdoor storage.
h) The Bidder shall warranty that characteristic of oil furnished shall comply with the requirements specified in IEC: 60296 with the latest amendment /revision and shall be suitable for EHV grade transformers.

(Note: The color of the barrels in which Naphthenic based transformer oil is to be supplied shall be Red)

Insulating oil shall be unused un-inhibited highly refined naphthenic base oil [not containing Polychlorinated Biphenyls (PCBs)], conforming to IEC 60396-2020 & all parameters specified at Annexure – 4(T) (attached), while tested at oil supplier's premises. The contractor shall furnish test certificates from the supplier against the acceptance norms as mentioned at Annexure – 4(T), prior to despatch of oil from refinery to site. The Unused Un Inhibited Insulating Oil parameters including parameters of oil used at manufacturer's works, processed oil, oil after filtration and settling are attached at Annexure – 4(T). The oil test results shall form part of equipment test report. Sufficient quantity of oil necessary for maintaining required oil level in case of leakage in tank, radiators, conservator etc. till the completion of warranty period shall be supplied

Oil used for first filling, testing and impregnation of active parts at manufacturer's works shall be of same type of oil which shall be supplied at site and shall meet parameters as per specification.

17.20.1.0 Particles in the oil

The particle analysis shall be carried out in an oil sample taken before carrying out FAT at manufacturer's works and after completion of the oil filtration at site. The procedure and interpretation shall be in accordance with the recommendation of CIGRE report WG-12.17- "Effect of particles on transformer dielectric strength". Particle limit as shown below shall be ensured by manufacturer, implying low contamination, as per CIGRE Brochure 157, Table 8. After filtration the oil is to be flushed and particle count to be measured.

Limiting value for the particle count are 1000 particle/100 ml with size ≥ 5 µm; 130 particle/100 ml with size ≥ 15 µm.

17.20.1.1 Oil filling

- Procedures for site drying, oil purification, oil filling etc. shall be done as per EMPLOYER Field Quality Plan (FQP).

- The duration of the vacuum treatment shall be demonstrated as adequate by means of water / dew point 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.

- Oil filling under vacuum at site shall be done with transformer oil at a temperature not exceeding 65°C. Vacuum shall not be broken until the Transformer is oil filled up to the Buchholz relays.

- 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.

- The Ultra High Vacuum type oil treatment plant (on returnable basis) of adequate capacity (**generally 6000** litres per hour and above) suitable for treatment of oil in EHV class Transformer shall be used. The plant shall be capable of treatment of new oil (as per IEC 60296) and reconditioning of used oil (as per IS: 1866/IEC: 60422 for oil in service) at rated capacity on single pass basis as follow:

  i) Removal of moisture from 100 ppm to 3 ppm (max.)
  ii) Removal of dissolved gas content from 10% by Vol. to 0.1% by vol.
  iii) Improvement of dielectric strength break down voltage from 20 to 70 KV
  iv) Vacuum level of degassing chamber not more than 0.15 torr/0.2 mbar at rated flow and at final stage. Machine shall have minimum of two degassing chambers and these should have sufficient surface areas to achieve the final parameters.
  v) Filter shall be capable of removing particle size more than 0.5 micron in the filtered oil.
  vi) Processing temperature shall be automatically controlled and have an adjustable range from 40 deg C to 80 deg C.

- The above oil treatment plant (Filtration unit) shall be arranged by the bidder at his own cost.

17.20.2.0 Transportation of Oil

The insulating oil for the Transformer shall be delivered at site generally not before 90 days from the date of commissioning, with prior information to the Employer, in view of risk involved in balk storage, pilferage and fire hazard. In case this oil is not filled in Transformer due to delay in commissioning, same oil shall be used only after testing and ensuring that oil parameters are well within the specified limits.

Insulating oil shall be delivered to the site in returnable oil drums / flexi bag / tanker. The oil drums / flexi bag / tanker shall be taken back without any extra cost to Employer within generally 45 days after utilisation of oil but in any case, before contract closing. However, the spare oil shall be delivered in non-returnable drums.

17.21.0 Valves

- All valves upto and including 100 mm shall be of gun metal or of cast steel/cast iron. Larger valves may be of gun metal or may have cast iron bodies with gun metal fittings. They shall be of full way type with internal screw and shall open when turned counter clock wise when facing the hand wheel.
- Suitable means shall be provided for locking the valves in the open and close positions. Provision is not required for locking individual radiator valves.
- Each valve shall be provided with the indicator to show clearly the position (open/close) of the valve.
- All valves flanges shall have machined faces. Drain valves/plugs shall be provided in order that each section of pipe work can be drained independently.
- All valves in oil line shall be suitable for continuous operation with transformer oil at 115 deg C.
- The oil sampling point for main tank shall have two identical valves put in series. Oil sampling valve shall have provision to fix rubber hose of 10 mm size to facilitate oil sampling.
- Valves or other suitable means shall be provided to fix various on-line condition monitoring systems to facilitate continuous monitoring.
- Gland packing/gasket material shall be of “O” ring of nitrile rubber for all the valve’s flanges. All the flanges shall be machined.
- Type of valves shall be used for transformer as per following table. The location, size of valves for other application shall be finalised during design review.

Sl. No.	Description of Valve	Type
1	Drain Valve	Gate
2	Filter valve	Gate
3	Sampling Valve	Globe
4	Radiator isolation valve	Butterfly
5	Buchholz relay isolation valve	Gate
6	Sudden pressure relay	Gate
7	OLTC- tank equalizing valve	Gate /Needle
8	OLTC Drain cum filling valve	Gate
9	Valve for vacuum application on Tank	Gate
10	Conservator Drain valve	Gate
11	Aircell equalizing valve	Gate/ Globe/Ball
12	Valve for Conservator vacuum (top)	Gate
13	Filter valve for Cooler Bank (Header)	Gate
14	Cooler Bank isolation valve	Butterfly
15	Pump Isolation valve	Butterfly
16	Valve for N2 injection (NIFPS)	Gate
17	Valve for NIFPS Drain	Gate
18	Valve for UHF Sensors	Gate

- Flow sensitive conservator Isolation valve:

a) In order to restrict the supply of oil in case of a fire in transformer, flow sensitive valve shall be provided to isolate the conservator oil from the main tank. The valve shall be flow sensitive and shut off when the flow in the pipe is more than the flow expected in the permissible normal operating conditions. It shall not operate when oil pumps are switched on or off. This valve shall be located in the piping between the conservator and the Buchholz relay and shall not affect the flow of oil from and to the conservator in normal conditions.

- When the flow from conservator to main tank is more than the normal operating conditions, the valve shall shut off by itself and will have to be reset manually. It shall be provided with valve open/close position indicator along with alarm contact indication in control room during closing operation of valve. This valve shall be provided with locking arrangement for normal position and oil filling / filtration position. A suitable platform or ladder (if required) shall be provided to approach the valve for manual reset. All valves shall be **Type Tested design** and painted with a shade (preferably red or yellow) distinct and different from of main tank surface and as per the painting system and procedure specified.
- All hardware used shall be hot dip galvanised/strainless steel.

17.21.2 Cabling

17.21.2.1 Buchholz Relay, Magnetic Oil Level Gauge, Pressure Relief Device & Sudden pressure relay to be wired through unarmoured cable of 1.5 sq.mm (minimum), inside GI conduit, with no part exposed. Cable shall be protected by flexible stainless-steel pipe, at both ends as per requirement. Proper sealing arrangement to be provided at both ends to avoid ingress of water.

The cross section of “control cable” shall be 1.5 sq.mm (minimum) except for CT circuits which should be 2.5 sq.mm (minimum).

All other cables shall be armoured type and shall be routed through covered cable tray or GI conduit and shall be properly dressed.

Cable terminations shall be through stud type TB and ring type lugs. Typical Technical specification for cables is attached at **Annexure-M** Contractor shall provide type tested cables from approved sources. No type testing for cables is envisaged. Both ends of all the wires (control & power) shall be provided with proper ferrule numbers for tracing and maintenance. Further, any special cables (if required) shall also be considered included in the scope. All cable accessories such as glands, lugs, cable tags/ numbers etc. as required shall be considered included in the scope of supply.

Cabling of spare unit with isolator switching arrangement 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 be brought in common marshalling box of all the banks. From CMB all the control, protection and indication signals of R, Y, B and Spare units shall be transferred to Purchaser’s Control panels / SCADA. Change-over of spare unit signals with faulty unit shall be done through Purchaser’s C & R panels / SCADA level. Changeover of RTCC signals shall be carried out in CMB.

17.22.0 Tap Changing Equipment

Each transformer shall be provided with On Load Tap changing equipment as specified elsewhere.

17.22.1.0 ON Load Tap Changing (OLTC) Equipment (Oil type)

17.22.1.1 Main OLTC Gear Mechanism

Each three-phase transformer shall be provided with voltage control equipment of the tap changing type for varying its effective transformation ratio whilst the transformers are on load.

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 oil 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.

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.

The OLTC oil chamber shall have oil filling and drain valve, oil sampling valve, relief vent and level glass. Oil sampling valve of minimum size, accessible from ground, shall be provided to take sample of oil from the OLTC chamber. It shall also be fitted with an oil surge relay which shall be connected between OLTC oil chamber and OLTC conservator tank.

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

17.22.1.2 Local OLTC Control Cabinet (Drive Mechanism Box)

Each transformer unit of OLTC gear shall have following features:

- 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.
- 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:
  a. Mechanical tap position indicator which shall be clearly visible from near the transformer.
  b. 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.
  c. Mechanical stops to prevent over-cranking of the mechanism beyond the extreme tap positions.
  d. The manual control considered as back up to the motor operated on load tap changer control shall be interlocked with the motor to block motor start-up during manual operation.
  e. The manual operating mechanism shall be labelled to show the direction of operation for raising the voltage and vice-versa.
  f. 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.

- 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. The Local OLTC Drive Mechanism Box shall house all necessary devices meant for OLTC control and indication. It shall be complete with the followings:

  i. A circuit breaker/contactor with thermal overload devices for controlling the AC auxiliary supply to the OLTC motor
  ii. Emergency Push Button to stop OLTC operation

iii. Cubicle light with door switch provided with anti-condensation metal clad heaters to prevent condensation of moisture
iv. Padlocking arrangement for hinged door of cabinet
v. All contactors relay coils and other parts shall be protected against corrosion, deterioration due to condensation, fungi etc.
vi. The cabinet shall be tested at least IP 55 protection class.

- All relays and operating devices shall operate correctly at any voltage within the limits specified below. In case 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.

Nominal Voltage	Variation in Voltage	Frequency in Hz	Phase/Wire	Neutral Connection
415 V	+/- 10%	50 +/- 5%	¾ Wire	Solidly earthed
240 V	+/- 10%	50 +/- 5%	½ Wire	Solidly earthed
220 V	190 V to 240 V	DC	Isolated 2 wire system	-
110 V	95 V to 120 V	DC	Isolated 2 wire system	-
48 V	-	DC	2 wire system (+) earthed	-

Note: Combined voltage and frequency shall be limited to +/- 10%

- In case 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.
- 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.
- Limit switches shall be provided to prevent overrunning 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.
- 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.
- '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.
- Following minimum contacts shall be available in DM Box, which shall be wired to CMB for single phase unit. Further these contacts shall be wired to Digital RTCC panel:

a. INCOMPLETE STEP which shall not operate for momentary loss of auxiliary power.
b. OLTC motor overload protection
c. Supply to DM Motor fail
d. OLTC IN PROGRESS
e. Local / Remote Selector switch position

f. OLTC upper/lower limits reached

- All relays, switches, fuses etc. shall be mounted in the OLTC local control cabinet and shall be clearly marked / labelled for the purpose of identification.
- A permanently legible lubrication chart if required shall be fitted within the OLTC local control cabinet.

17.22.1.3 OLTC Control from Common Marshalling Box (CMB)

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 (1-Ph) 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.

Independent-combined-remote selector switch, raise/lower switch and emergency stop Push Button shall be provided in the common marshalling box for OLTC control.

When the selector switch is in **independent** position, the OLTC control shall be possible from individual Local OLTC Control Cabinet (DM Box) only.

In '**combined position'**, raise-lower switch (provided in the CMB), shall be used to operate for bank of three single phase transformers from CMB.

In **'remote position'** control of OLTC shall be possible from Digital RTCC/SCADA etc.

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.

Following minimum **LED indications** shall be provided in CMB:

a. INCOMPLETE STEP
b. OLTC motor overload protection
c. Supply to DM Motor fail
d. OLTC IN PROGRESS
e. Local / Remote Selector switch positions of DM
f. OLTC upper/lower limits reached
g. 415V Main AC supply ON
h. 415V Standby AC supply ON.

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

a) 415V Main AC supply Fail
b) 415V Standby AC supply Fail

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

(a) INCOMPLETE STEP
(b) OLTC motor overload protection
(c) Supply to DM Motor fail
(d) OLTC IN PROGRESS
(e) Local / Remote Selector switch positions of DM
(f) OLTC upper/lower limits reached
(g) 'Independent-combined-remote' selector switch positions of CMB

Further, OLTC Tap position Digital indications for all three 1-Ph Transformer 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.

17.23.0 Digital RTCC Panel

The digital RTCC relay 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 contractor shall also provide Digital RTCC panel consisting of 4 Nos. Digital RTCC relays. Further, one spare Digital RTCC relay shall also be provided in the same panel. Each digital RTCC relay shall be used to control 1 bank of transformers (i.e., 1 No. 3-Phase unit)

Digital RTCC relay shall be microprocessor based adopting the latest state of the art design & technology with in-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.

The 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 for control of OLTC. Touch screen option in the relay, instead of electrical push button/switch is also acceptable.

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.

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.

Master / Follower/ Independent/ Off mode
Master / Follower parallel operation is required with Group simultaneous feature in Digital RTCC relay. Master-follower scheme implies that controlled decision shall be taken by the Master and control actions (Raise/Lower tap position) shall be executed simultaneously by Master & Follower units. Same logic needs to be implemented in digital RTCC relays.

Master Position: If the digital RTCC relay is in master position, it shall be possible to control the OLTC units of other parallel operating transformers in the follower mode by operation from the master unit.

Follower Position: If the digital RTCC relay is in Follower position, control of OLTC shall be possible only from panel where master mode is selected.

Independent Position: In independent position of selector switch, control of OLTC shall be possible only from the panel where independent mode is selected. Suitable interlock arrangement shall be provided to avoid unwanted/inconsistent operation of OLTC of the transformer

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.

Digital RTCC relays shall communicate with SCADA using IEC 61850 through FO port to monitor, parameterise & 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 analysing 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 these 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 bidder.

The Digital RTCC relay shall have additional 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.

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 affected. If the command remains in the "operate" position, lock-out of the mechanism is to be ensured.

Following minimum indications/alarms shall be provided in Digital RTCC relay either through relay display panel or through relay LEDs:

a. INCOMPLETE STEP alarm
b. OLTC motor overload protection alarm
c. Supply to DM Motor fail alarm
d. OLTC IN PROGRESS alarm
e. Local / Remote Selector switch positions in DM Box
f. OLTC upper/lower limits reached alarm
g. OLTC Tap position indications for transformer units
h. Independent-combined-remote selector switch positions of CMB (In case of single-phase transformer)
i. 415V, AC Mail Supply Fail.
j. 415V, AC Standby Supply Fail

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

17.24.0 SCADA Integration and Interconnection

All required power & control cables including optical cable, patch chord (if any) upto MB (for 3-Ph unit) shall be in the scope of contractor. Further, any special cable between MB (for 3-Ph unit) to switchyard panel room/control room shall be under the present scope. All cable from RTCC to OLTC Drive Mechanism Box shall be provide (if applicable).

Fiber optic cable, power cable, control cables, as applicable, between MB (for 3-Ph unit) or Common MB (for 1-Ph unit) to switchyard panel room/control room and power supply (AC & DC) to MB and integration of above said IEC-61850 compliant equipment with Substation Automation System shall be under the scope of EPC contractor.

Cooling and OLTC of transformers shall be monitored and controlled from SCADA.

SCADA Integration of online monitoring equipment (if applicable):

All the online monitoring equipment i.e., Online Dissolved Gas (Multi-gas) and Moisture Analyser, On-line insulating oil drying system (Cartridge type) etc. provided for individual transformer unit including Spare (if any), are IEC 61850 compliant (either directly or through a Gateway). The monitoring equipment are required to be integrated with SAS through managed Ethernet switch conforming to IEC 61850. This Ethernet switch shall be provided in IMB or CMB. The switch shall be powered by redundant DC supply (110V or as per available Station DC supply). Ethernet switch shall be suitable for operation at ambient temperature of 50 Deg. C.

17.25.0 Constructional features of Cooler Control Cabinet/ Individual Marshalling Box/ Common Marshalling Box/ Junction Box / Outdoor cubicle and Digital RTCC Panel:

Each transformer unit shall be provided with local OLTC Drive Mechanism Box, cooler control cabinet /individual marshalling box, Digital RTCC panel (as applicable) and common marshalling (for a bank of three 1-phase units) shall be provided.

Common marshalling box (for single phase unit) shall be floor mounted and of size, not less than 1600mm (front) X 650mm (depth) X 1800mm (height). Individual Marshalling Box and Cooler control Box shall be tank mounted or ground mounted. The gland plate hall be at least 450 mm above ground level (for ground mounted panel).

The cooler control cabinet / individual marshalling box, common marshalling box, Junction box and all other outdoor cubicles (**except OLTC Drive Mechanism box**) shall be made of stainless-steel sheet of minimum grade of SS304 and of minimum thickness of 1.6 mm (SS 316 for coastal area). Digital RTCC panel shall be made of CRCA sheet of minimum thickness of 2.5mm and shall be painted suitably as per **Annexure –D**.

The degree of protection shall be IP: 55 for outdoor and IP: 43 for indoor in accordance with IS 13947/IEC: 60947.

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.

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.

The size of Common marshalling box shall not be less than 1600mm (front) X 650mm (depth) X 1800mm (height). All the separately mounted cabinets and panels shall be free standing floor mounted type and have domed or sloping roof for outdoor application.

17.26.0 Current Transformer

Current transformers shall comply with IS 16227 (Part 1 & 2)/IEC 61869 (part 1 & 2).

It shall be possible to remove the turret mounted current transformers from the Transformer 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 common marshalling box using separate cables for each core.

Technical Parameters of Bushing CTs and Neutral CTs are enclosed at **Annexure – G.** The CT's used for REF protection must have the identical parameters in order to limit the circulating current under normal condition for stability of protection. Bushing Current transformer parameters indicated in this specification are tentative and liable to change within reasonable limits. The Contractor shall obtain Purchaser's approval before proceeding with the design of bushing current transformers.

Secondary resistance and magnetising current characteristics of PX class (protection) (as per IEC) CT of same rating shall be similar. This is applicable for Neutral CT (outdoor) also and shall be reviewed during detail engineering.

17.27.0 Hand Tools:

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 used - 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), bushing handling and lifting tools with nylon rope/belt, chain block (2 Nos.) and D-Shackle shall be supplied.

17.28.0 Test Kit:

BDV Kit as per Annexure-N of specification.
Portable DGA Kit as per Annexure-O of Specification.

17.29.0 Fittings & accessories

The following fittings & accessories (as applicable) shall be provided with each transformer covered in this specification. The fittings listed below are not exhaustive and other fittings which are required for satisfactory operation of the transformer are deemed to be included:

- Conservator for main tank with aircell, oil filling hole and cap, isolating valves, drain valve, magnetic oil level gauge (with canopy) with high and low oil level alarm contacts and prismatic oil level gauge and Dehydrating Silicagel Filter Breather with flexible connection pipes to be used during replacement of any silicagel breather.

  Conservator for OLTC with drain valve, oil surge Relay, filling hole with cap, prismatic oil level gauge and Dehydrating Silicagel Filter Breather with flexible connection pipes to be used during replacement of any silicagel breather.

- Oil preservation equipment, Thermosyphon filter with valves.
- Pressure relief devices including canopy with special shroud to direct oil
- Sudden pressure relief relay including canopy.
- Buchholz relay double float, reed type with canopy and isolating valves on both sides, bleeding pipe with pet cock at the end to collect gases and alarm / trip contacts (gas collecting device)
- Air release plug
- Conservator air cell rupture detection relay
- Inspection openings and covers
- Bushing of each type with metal parts and gaskets to suit the termination arrangement
- Winding & Oil temperature indicators
- Cover lifting eyes, transformer lifting lugs, jacking pads, towing holes and core and winding lifting lugs
- Protected type mercury or alcohol in glass thermometer or magnetic or micro-switch type dial type temperature indicator as applicable
- Rating and diagram plates (in Hindi & English) on transformers and auxiliary apparatus
- Roller Assembly (as per clause 17.10.1.6)
- On load tap changing gear, OLTC DM Box, Off Circuit Tap Changer (OCTC) individual marshalling box / Cooler control cabinet, Common Marshalling Box, Fibre optic sensor box and Digital RTCC Panel as applicable
- Cooling equipment
- Bushing current transformers, Neutral CT (if applicable)
- Oil flow indicators (if applicable)
- Terminal marking plates
- Valves schedule plate & All the valves as per clause 17.13.1.1.4, 17.13.1.1.7 and 17.21.1.
- **Valves List**: Bottom oil sampling valve, Drain valves, Filter valves at top and bottom with threaded male adaptors, Shut off valves on the pipe connection between radiator bank and Transformer tank, Shut off valves on both sides of Buchholz relay, Sampling gas collectors for Buchholz relay at accessible height, Valves for Radiators, Valve for vacuum application, Valve for on line DGA, valves for Drying out system, Flow sensitive conservator Isolation valve, Valve for UHF sensors, valves for NIFPS system etc.
- Ladder (suitably placed to avoid fouling with bushing or piping) to climb up to the transformer tank cover with suitable locking arrangement to prevent climbing during charged condition. Additional ladder for conservator in case it is not tank mounted.
- Suitable Platform for safe access of Flow sensitive non-return valve and buchholz relay shall be provided, in case these are not accessible from transformer top.
- Haulage lugs
- Neutral bus connection arrangement. (3-Phase Transformer)
- Brass/tinned copper grounding bar supported from the tank by using porcelain insulator and flexible conductor for earthing of neutral, HV & IV terminals.
- On line insulating oil drying system.
- Online Dissolved Gas (Multi-gas) and Moisture Measuring Equipment
- On line dissolved Hydrogen and Moisture Measuring Equipment
- Fibre optic sensor-based temperature measuring system.
- Nitrogen Injection Type Fire Prevention & Extinguishing System.
- Automatic Mulsifire System (or High Velocity Water Spray System)
- RTCC All Cables (Power, control and shielded / twisted pair for 4-20mA cable from Transformer MB, Cooler control cubicle, etc. (as applicable) to CMB shall be under the present scope. Any special cable if required to be included upto panel/ employer’s C&R panel.
- Managed Ethernet switch, LIU patch cords etc. shall be provided in CMB/MB. All IEC 61850 compliant signals from various monitoring equipment/accessories shall be wired upto the Ethernet switch.

17.30.0 Inspection and Testing

The Contractor shall carry out a comprehensive inspection and testing programme during manufacture of the equipment. The inspection envisaged by the Purchaser is given below. 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 Purchaser for necessary implementation. All accessories and components of transformer shall be purchased from approved soured of purchaser. All process tests, critical raw material tests and witness / inspection of these testing shall be carried out as per approved manufacturing quality plan (MQP) by purchaser.

17.31.0 Factory Tests

The manufacturer shall be fully equipped to perform all the required tests as specified. Bidder shall confirm the capabilities of the proposed manufacturing plant in this regard when submitting the bid. Any limitations shall be clearly stated in.
The contractor shall bear all additional costs related to tests which are not possible to carry out at his own works.
The contractor shall carry out type & routine tests as per "**Annexure-H & Annexure-I".** All tests shall be done in line with IEC: 60076 and the test procedures as mentioned in "**Annexure-H".** Complete test report shall be submitted to purchaser after proper scrutiny and signing on each page by the test engineer of the contractor.

17.32.0 Type Tests on fittings:

Following fittings shall conform to type tests and the type test reports shall be furnished by the contractor along with drawings and GTP of the equipment / fittings.

1) Bushing (Type Test as per IEC:60137 including Snap back & Seismic test for 400 kV and above voltage class bushing)
2) OLTC (Test as per IEC:60214 and IP-55 test on driving mechanism box)
3) Buchholz relay
4) OTI & WTI
5) Pressure Relief device Test (including IP 55 test in terminal box)
6) Sudden Pressure Relay Test (including IP 55 test in terminal box)
7) Magnetic Oil Level gauge & Terminal Box for IP-55 degree of protection.
8) Air Cell (Flexible air separator) - Oil side coating, Air side under Coating, Air side outer coating and coated fabric as per IS: 3400/ BS: 903/ IS: 7016
9) Marshalling & common marshalling box and other outdoor cubicle (IP-55 test)
10) RTCC (IP-43)

17.33.0 Pre-Shipment Checks at Manufacturer's Works

Check for inter-changeability of components of similar transformers for mounting dimensions.

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

Before dispatch of Transformer from factory, following impact recorder settings are to be implemented for graphical analysis:

> 1g: Start recording
> 2g: Warning
> 3g: Alarm

Further, drop-out setting shall be 1g and threshold setting shall be in the range of 5g to 10g.

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

Gas tightness test to confirm tightness and record of dew point of gas inside the tank. Derivation of leakage rate and ensure the adequate reserve gas capacity.

17.34.0 Inspection and Testing at Site

The Contractor 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 Purchaser is given below. However, it is contractor's responsibility to draw up and carry out such a programme duly approved by the Purchaser. Testing of oil sample at site shall be carried out as per specification.

17.35.0 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.

17.36.0 Installation Checks

Inspection and performance testing of accessories like tap changers, cooling fans, oil pumps etc. Check the direction of rotation of fans and pumps and check the bearing lubrication. 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 gas in the main tank before assembly.

17.37.0 Commissioning Checks

Check the colour of silicagel in silicagel breather. Check the oil level in the breather housing, conservator tanks, cooling system, condenser bushing etc.

Check the bushing for conformity of connection to the lines etc.
Check for correct operation of all protection devices and alarms/trip:
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

Check for the adequate protection on the electric circuit supplying the accessories.

Check resistance of all windings on all steps of the tap changer. Insulation resistance measurement for the following:

i) Control wiring
ii) Cooling system motor and control
iii) Main windings
iv) Tap changer motor and control

Check for cleanliness of the transformer and the surroundings.

2 kV for 1-minute test between bushing CT terminal and earth.
Phase out and vector group test.
Ratio test on all taps.

Magnetising current test.
Capacitance and Tan delta measurement of winding and bushing.
Frequency response analysis (FRA). FRA equipment shall be arranged by purchaser.

DGA of oil just before commissioning and after 24 hours energisation at site.
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.

Continuously observe the transformer operation at no load for at least 24hours.
Contractor shall prepare a comprehensive commissioning report including all commissioning test results as per Pre-Commissioning Procedures forward to Purchaser for future record.

17.38.0 NITROGEN INJECTION TYPE FIRE PREVENTION & EXTINGUSHING SYSTEM

Nitrogen Injection Type Fire Protection System (NIFPS) shall be designed to prevent explosion of transformer tank and the fire during internal faults resulting from arc and also to extinguish the external oil fires on transformer due to tank explosion and/or external failures like bushing fires, OLTC fires and fire from surrounding equipments, etc.

The system shall work on the principle of Drain & stir. On activation, it shall drain a predetermined quantity of oil from the tank top through drain valve to reduce the tank pressure, isolate conservator tank oil and inject nitrogen gas at high pressure from the bottom side of the tank through inlet valves to create stirring action and reduce the temperature of oil below flash point to extinguish the fire. On operation, the quantity of oil removed from the tank shall be such that adequate amount of oil shall remain to cover active part (i.e., core coil assembly). Electrical isolation of transformer shall be an essential pre-condition for activating the system.

NIFPS system shall be supplied with operating curves indicating the actuation time of various sensors and nitrogen injection. For NIFPS system, probes and sensor locations shall not be placed inside the transformer.

17.38.1.0 Operational Controls

The system operation shall be fully automatic and activate from the required fire and other trip signals. In addition to automatic operation, remote operation from control room/ remote centre and local manual control in the fire extinguishing cubicle shall also be provided. System shall operate on following situations:

17.38.1.1 Prevention of transformer from explosion and fire

To prevent transformer from explosion and fire in case of an internal fault, signals given by operation of Electrical protection relays and tripping of circuit breaker of transformer and operation of either Buchholz relay or pressure relief valve (PRV) shall be used to activate the system. The exact logic for system activation shall be finalized during detailed engineering.

17.38.1.2 Prevention of transformer from fire

In case of fire, sensed by fire detectors, the system shall be activated only after electrical isolation of the transformer, confirmed by breaker trip. If the fire detection is not associated with any other fault, the system activation shall be only manual. Manual operation switch shall be provided in the control room with a cover to avoid accidental operation of it.

17.38.2.0 Operation of System

On receiving activation signal, the following shall take place:

i) Open the quick opening drain valve to drain the top layer oil

ii) Shut off the conservator isolation valve to prevent flow of oil from the Conservator tank to the main tank

iii) Open the Nitrogen regulator valve to inject Nitrogen into the transformer tank to create stirring of oil.

There shall be interlock to prevent activation of the system if the transformer is not electrically isolated.
There shall also be provision for isolating the system during maintenance and/or testing of the transformer.

17.38.3.0 Technical Particulars

The contractor shall be responsible for the design of the complete system and shall submit the drawings and design calculations for the number of fire detectors, pipe sizing of drain pipe and Nitrogen injection pipe, Nitrogen cylinder capacity, number of injection points, etc. and get approval from AEGCL.
Facility shall be provided to test the system when the transformer is in service, without actually draining the oil and injecting Nitrogen.

The Nitrogen regulator valve shall be designed in such a way that the Nitrogen shall not enter the transformer tank even in case of passing/ leakage of valve.

Owner shall provide two distinct station auxiliary DC feeders for control purposes. The system shall work on station DC supply with voltage variation defined in Data Sheet. The control box of fire protection system shall have facility to receive these feeders for auto changeover of supply. It shall be the contractor’s responsibility to further distribute power to the required locations. In case auxiliary DC power supply requirement is different than station auxiliary DC supply, then all necessary DC-DC converters shall be provided by the Contractor.

Following minimum indications and alarms shall be provided in the local cubicle as well as in the control box:-

- Nitrogen cylinder pressure indication - manometer with sufficient number of adjustable NO contacts
- Nitrogen cylinder pressure low
- Fire in Transformer
- Oil drain started
- Conservator oil isolation valve closed
- Nitrogen injection started
- DC supply fail
- Oil drain valve closed
- Gas inlet valve closed

17.38.4.0 Details of Supply of System Equipment and Other Related Activities:

The scope of supply shall include the following items and any other items required for safe and trouble free operation of the system.

i) Fire extinguishing cubicle with base frame and containing at least the following:

- Nitrogen gas cylinder of sufficient capacity with pressure regulator and manometer with sufficient number of adjustable NO contacts.
- Oil Drain Assembly including oil drain pipe extension of suitable size for connecting pipes to oil pit
- Mechanical release device for oil drain and nitrogen release
- Limit switches for monitoring of the systems
- Panel lighting
- Flanges on top of the panel for connecting oil drain and nitrogen injection pipes for transformer
- Back up pressure switch to operate nitrogen gas valve
- Pressure indicators for Nitrogen pressure of the cylinder and actual injection through Nitrogen regulator

ii) Control box to be installed in the control room of the station for monitoring system operation, automatic control and remote operation, with alarms, indications, switches, push buttons, audio signal, suitable for tripping and signalling.

iii) Required number of fire detectors to be located in strategic locations to be finalized during detailed engineering.

iv) All controls, alarms, panels, cables, cable trays (if required), junction boxes etc.

Detailed specification of Nitrogen Injection Type Fire Protection System (NIFPS) shall be as per **Annexure-R.**

17.39.0 Under Ground Oil Storage Tank

Each transformer unit shall be provided with an underground oil storage tank. The oil storage tank shall have non-Corrosive, water proof, epoxy coated (from Inside) mild steel (minimum thickness 6 mm) to store drained out oil on operation of NIFPS. The tank shall be painted from outside as per Clause 17.16.0. The total capacity of storage tank shall be at least 10% of transformer tank oil to avoid overflowing of oil considering that drained oil volume shall be around 10% of transformer tank oil. Necessary arrangement shall be made on underground storage tank so as to take out the drained oil from the tank for further processing and use. All the pipe and physical connection from transformer to oil pit shall be in the scope of contractor.

This storage tank shall be placed in the pit made of brick walls with PCC (1:2:4) flooring with suitable cover plates to avoid ingress of rain water. The design of tank and pit shall be finalized during detailed engineering. **All underground oil and gas storage tanks design shall be certified by petroleum and explosive safety organisation, Nagpur, India.**

17.39.1.1 Installation and pre-commissioning test

After installation the system pre-commissioning tests shall be carried out jointly with the Owner’s representative before the system is put in service.

17.39.1.2 Online Insulating oil drying system

On-line insulating oil drying system (Cartridge type) along with all required accessories shall be provided with each transformer. In addition to provision of air cell in conservators for sealing of the oil system against the atmosphere, each transformer shall be provided with an on-line insulating oil drying system of adequate rating with proven field performance. This system shall be tank/cooler bank mounted and no separate foundation shall be provided. This on-line insulating oil drying system shall be

(i). Designed for very slow removal of moisture that may enter the oil system or generated during cellulose decomposition. Oil flow to the equipment shall be controlled through pump of suitable capacity.

(ii). The equipment shall display the moisture content in oil (PPM) of the inlet and outlet oil from the drying system. The moisture in inlet & outlet oil (PPM) shall have to be displayed in Local SCADA besides local HMI.

(iii). Minimum capacity of moisture extraction shall be 10 Litres before replacement of cartridge.

Calculation to prove the adequacy of sizing of the on line insulating oil drying system along with make and model shall be submitted for approval of purchaser during detail engineering.

The equipment shall be supplied with Operation Manual (2 set for every unit), Software (if any), and Compact disc giving operation procedures of Maintenance Manual & Trouble shooting instructions.

Addition detailed specification of On-line insulating oil drying system shall be as per **Annexure-Q**

17.40.0 On Line Dissolved Hydrogen and Moisture Monitor

The Monitor shall be a microprocessor based Intelligent Electronic Device (IED), designed to continuously detect and measure dissolved Hydrogen and Water content, even at very low concentrations, in Transformer Oil. It should be easy to install and it should be possible to retrofit it on an energized transformer, without shutting down the transformer.

The monitor shall be designed for permanent outdoor use in high voltage sub-station environments, for ambient temperatures of 0 deg C to 55 deg C and oil temperatures of 5 deg C to 105 deg C.

The monitor shall be suitable to detect and measure dissolved Hydrogen in ppm, without significant interference from other fault and atmospheric gases. The monitor shall also be suitable to detect Water Content measured in ppm.

The Hydrogen sensors shall have long lifetime in oil. The sensors shall be able to withstand pressure from vacuum to 10 psi.

17.40.1.0 Technical Parameters:

Sr. No.	Parameters	Requirements
1	**The measurement range / Output:**	
	Hydrogen Dissolved in oil	0 to 2000 ppm, with 4 – 20 mA output
	Water Dissolved in oil	0 to 95% RS, with 4 – 20 mA

		output
2	**Alarms/Indication (High & Very High)**	
	Hydrogen	Programmable NO/NC contacts,
	Water	Programmable NO/NC contacts,
3	**Environment**	
	Operating Ambient Temperature	0 to + 55 deg C
	Operating Oil Temperature	5 to + 105 deg C
	Pressure Withstand, (Oil side)	Full Vacuum to 10 psi.
4	Exterior enclosure and components	made of corrosion proof material to IP - 55
5	Communications	RJ45/RS–232 ports and suitable for Ethernet connectivity

Addition detailed specification of On-Line Dissolved Hydrogen and Moisture Monitor shall be as per **Annexure-P**

17.41.0 Condition Controlled Maintenance Free Type Breather

The main Transformer tank conservator shall be fitted with a Maintenance-Free type silica gel **(Colour: Orange)** Breather which shall be equipped with a humidity sensor, a condition-based microprocessor control unit and LED status indication.

17.41.1.0 Dehydrating breather's operating principle:

When the oil conservator breaths-in (e.g., at reduced load), the air flows through a filter made of high-grade steel wire mesh. The equipment fitted with filter & the dust cap, filters the dust, sand and other dirt particles from the air. The filtered air flows through the desiccant chamber filled with colourless, moisture absorbing pellets and are dehydrated. The dehydrated air rises further via the pipe in the oil conservator. The desiccant is dehydrated by the built-in heating unit which is controlled by sensors, thus obviating the need for periodic desiccant replacement. The dehydrating breather is mounted on the pipe to the oil conservator at a height of 1200 mm approximately from transformer rail top level.

17.41.1.1 Technical Features:

Material & External Construction of the Breather shall be such that all external parts are suitable for outdoor use & resistive to transformer oil, ultraviolet rays, pollution & salt water and shall work without any trouble for ambient temperature between 0^{o} C to $+80^{o}$ C.

Following LEDs for local display on control unit, and suitable contacts & analog signal shall be provided for wiring to remote location:

a. LED for Power of control unit - ON
b. LED for Filter heater- ON
c. LED for Anti-condensation heater (of control unit) - ON
d. LED & relay contact for "Device Error"
e. LED & relay contact for Regeneration active (De-humidification in process)
f. Analogue output signal (4-20mA) for the Temperature of air (in filter unit / pipe).

The Breather shall be equipped with test button which should allow to carry out a self-test and to check the functions like relay circuits, heating or the signal transmission in the control room, etc. at any time.

Control unit shall be equipped with a USB / RS 485 port for downloading the operational data logged by the unit. All necessary software required for downloading and analysing the logger data shall also be provided by the supplier. Supply of Laptop/PC for above software is not envisaged.

The moisture and temperature measurement system (sensor) installed should be modular making it easy to replace the same if at all the same is necessary during the service of breather.

The equipment shall operate at input supply of 230V AC, 50 Hz. Any converter if required shall be supplied with the equipment.

Degree of Protection shall be at least IP55 for which type Test report shall be submitted. Necessary protective devices shall be provided in order to protect the equipment against over voltages & high frequency interference.

The control unit shall be equipped with suitable heater to prevent moisture condensation.

The size of Condition controlled maintenance free dehydrating breather shall be decided based on the volume of transformer oil during detailed engineering.

For OLTC conservator, conventional breather shall be supplied as per technical specification.

Condition Controlled Maintenance Free Type Breather of alternate proven technology shall also be acceptable.

Addition detailed specification of Condition Controlled Maintenance Free Type Breather shall be as per **Annexure-U**

17.42.0 Automatic Mulsifire System (or High Velocity Water Spray System)

17.42.1.0 Description:

This system is widely used for firefighting of outdoor transformers. Spray type fire protection essentially consists of a network of projectors and an array of heat detectors used to sense high temperature near the transformer to be protected. If the temperature exceeds the set value, the automatic mulsifire system sprays water at high pressure through a Deluge valve from the pipe network laid for this system. Fire detectors located at various strategic points are on the surface of the transformer to control fire on any burning oil spilled over.

17. 43.1.1 Subsystems used to make a complete mulsifire system:

a) Main Hydrant

The main hydrant system shall be designed based on NFPA-16. This is used to carry the water to various parts of the switchyard ot transformer substation and forms the backbone of the system. Sturdy corrosion-free pipes and valves are used for this purpose. The materials should be able to withstand fire for a withstand fire for a reasonable duration.

b) Fire Detector

Fire detectors can either be thermocouples or specially designed bulbs which burst when they experience a high temperature and release any valves or checking device to start the water supply.

c) Ring Mains and Nozzles

Ring mains, which surround the transformer are provided to feed the water to the nozzles at various levels. Since the water pressure is high, the ring mains should be designed to withstand this pressure. Nozzles should be located such that the water spray, in the event of a fire, envelopes the entire surface of the transformer. The whole system should be periodically checked to detect any leakages.

Pumps

Pumps are provided to fill the hydrants initially and to maintain its pressure. Pumps driven by electrical motors are a standard provision; however, the standby pumps should preferably be diesel engine driven. It is recommended that the main and standby pumps in a pump house be segregated.

17.43.1.2 Electrical Safety

As per IEEMA specification, from safety considerations, the following electrical clearances are recommended between the mulsifier system pipe work and live parts of the transformer to be protected.

▪ 420 kV bushing	3500 mm
▪ 245 kV bushing	2150 mm
▪ 145 kV bushing	1300 mm
▪ 52 kV bushing	630 mm
▪ 36 kV bushing	320 mm

17.43.1.3 Installation Care

- Deluge Valve shall be water pressure operated manual reset type.
- Each Deluge valve shall be provided with a local panel from which will enable manual electrical operation of the valve.
- In addition to this, each valve shall be provided with local operation latch.
- Test valves shall simulate the operation of Deluge valves and shall be of quick opening type.

17.44.0 Transformer – Connection to GIS:

Transformer connection enclosure shall be part of gas insulated metal enclosed switchgear which shall house one end of a completely immersed bushing fitted on a power transformer and main circuit end terminal of GIS. The transformer connection enclosure shall be designed as per the recommendations of IEC 62271-211 and the limit of supply of switchgear manufacturer and the transformer manufacturer shall also be as per the scope mentioned in the IEC. The switchgear manufacturer shall supply connection between the enclosures of different phases as per requirement to limit the circulating current in the transformer tanks. The manufacturer of the connection enclosure shall take into account the total dynamic forces generated during short circuit and the enclosure as well as bushings shall be capable of withstanding vacuum during evacuation process. The

switchgear manufacturer shall make necessary arrangement to limit the very fast front transient ground potential rises which may occur during switching operation. The detailed scope of transformer manufacturer and GIS manufacturer as per IEC 62271-211.
Suitable spring bellows shall be provided on the connecting GIS busduct at suitable location to prevent any vibration generating from transformer to GIS busduct.

17.45.0 CENTRE OF GRAVITY:

The center of gravity of assembled transformer shall be as low and as near the vertical center line as possible. The transformer shall be stable with and without oil. The location of the center of gravity, relative to track shall be clearly marked in the outline drawing, accompanying bid.

Annexure – A 1.0

Technical Particulars / Parameters of Transformers (500MVA [3 phase] 400/220/33 kV, Auto Transformer): Annexure-2(T) (Attached)

ClauseNo.	Description	Unit	Technical Parameters
1.1	Rated Capacity		
	HV	MVA	500
	IV	MVA	500
	LV (Tertiary)	MVA	5MVA (Thermal loading)
1.2	Voltage ratio (Line to Line)		400/220/33
1.3	Vector Group (3-Phase)		YNaOd11
1.4	Single / Three Phase Design		3 (THREE)
1.5	Applicable Standard		IEC 60076 / IS 2026
1.6	Cooling		ONAN / ONAF / OFAF or ONAN / ONAF / ODAF
1.7	Rating at different cooling	%	60 / 80 / 100
1.8	Cooler Bank Arrangement		2 X 50%
1.9	Frequency	Hz	50
1.10	Tap Changer (OLTC)		+10% to -10% in 1.25% steps on common end of series winding for 400kV side voltage variation
1.11	Type of Transformer		Constant Ohmic impedance type (Refer note 1)
1.12	Impedance at 75 Deg C		
	HV – IV		
	Max. Voltage tap	%	10.3
	Principal tap	%	12.5
	Min. Voltage tap	%	15.4
	HV – LV		
	Principal tap (minimum)	%	60.0

	IV – LV		
	Principal tap (minimum)	%	45.0
1.13	Tolerance on Impedance (HV-IV)	%	As per IEC, unless specified otherwise
1.14	Service		Outdoor
1.15	Duty		Continuous
1.16	Overload Capacity		IEC-60076-7
1.17	Temperature rise over 50 deg C ambient Temp		
i)	Top oil measured by thermometer	^{O}C	45
ii)	Average winding measured by resistance method	^{O}C	50
1.18	Winding hot spot rise over yearly weighted temperature of 32 ^{O}C	^{O}C	61
1.19	Tank Hotspot Temperature	^{O}C	110
1.20	Maximum design ambient temperature	^{O}C	50
1.21	Windings		
i)	Lightning Impulse withstand Voltage		
	HV	kVp	1300
	IV	kVp	950
	LV	kVp	250
	Neutral	kVp	95
ii)	Chopped Wave Lightning Impulse Withstand Voltage		
	HV	kVp	1430
	IV	kVp	1045
	LV	kVp	275
iii)	Switching Impulse withstand Voltage		
	HV	kVp	1050
iv)	One Minute Power Frequency withstand Voltage		
	HV	kVrms	570
	IV	kVrms	395
	LV	kVrms	95
	Neutral	kVrms	38
v)	Neutral Grounding		Solidly grounded
vi)	Insulation		
	HV		Graded
	IV		Graded
	LV		Uniform
vii)	Tertiary Connection		Ungrounded Delta
viii)	Tan delta of winding	%	≤ 0.5
1.22	Bushing		
i)	Rated voltage		
	HV	kV	420
	IV	kV	245
	LV	kV	72.5
	Neutral	kV	36

ii)	Rated current (Min.)		
	HV	A	1250
	IV	A	2000
	LV	A	3150
	Neutral	A	2000
iii)	Lightning Impulse withstand Voltage		
	HV	kVp	1425
	IV	kVp	1050
	LV	kVp	325
	Neutral	kVp	170
iv)	Switching Impulse withstand Voltage		
	HV	kVp	1050
	IV	kVp	850
v)	One Minute Power Frequency withstand Voltage		
	HV	kVrms	695
	IV	kVrms	505
	LV	kVrms	155
	Neutral	kVrms	77
vi)	Minimum total creepage distances		(Specific creepage distance: 31mm/kV corresponding to the line to line highest system voltage)
	HV	mm	13020
	IV	mm	7595
	LV	mm	2248
	Neutral	mm	1116
vii)	Max Partial discharge level at Um		
	HV	pC	10
	IV	pC	10
	LV	pC	10
	Neutral		-
1.23	Max Partial discharge level at 1.58 * Ur / √3	pC	100
1.24	Max Noise level at rated voltage and at principal tap at no load and all cooling active	dB	80
1.25	Maximum Permissible Losses of Transformers		Same for constant ohmic And constant percentage type
i)	Max. No Load Loss at rated voltage and frequency	kW	90
ii)	Max. Load Loss at rated current and frequency at75°C between HV and IV windings, at principal tap position	kW	500
iii)	Max. I2R loss at rated current and at 75°C for HV and IV at principal tap	kW	375
iv)	Max. Auxiliary Loss at rated voltage and frequency	kW	15

Notes:

1. For parallel operation with existing transformer, the impedance, OLTC connection & range and the winding configuration (if necessary) is to be matched.
2. No external or internal Transformers are to be used to achieve the specified HV/IV, HV/LV and IV/LV impedances.
3. Tan delta of Winding & Bushing shall be measured at ambient temperature. No temperature correction factor shall be applied.
4. The criteria for Transformer losses shall be "**Copper Loss (Load Loss) > Iron Loss (No Load Loss) > Cooler Loss (Auxiliary Loss)".**
5. External minimum clearances in air for Phase to Phase and Phase to Earth shall be providedas per IS 2026 (Part 3) / IEC60076-3

Annexure – A 2.0

Technical Particulars / Parameters of Transformers (220/132/33 kV 160 MVA & 200 MVA 3-Phase Auto

Cl. No.	Description	Unit	TECHNICAL PARAMETERS	
1.	Rated Capacity			
	HV	MVA	**160**	
	IV	MVA	**160**	
	LV (Tertiary)	MVA	5 MVA active loading	
2.	Voltage ratio	kV	220/132/33	
3.	Single / Three Phase Design		3 (Three)	
4.	Applicable Standard		IEC 60076 /IS 2026	
5.	Frequency	Hz	50	
6.	Cooling & Percentage Rating at different cooling		ONAN/ONAF/ (OFAF or ODAF): 60% / 80%/100%	
7.	Cooler Bank Arrangement		2 X 50%	
8.	Type of Transformer		Constant Ohmic impedance type	Constant percentage impedance type
9.	HV-IV Impedance at 75 Deg C			
i)	Max. Voltage tap	%	10.3	13.0
ii)	Principal tap	%	12.5	12.5
iii)	Min. Voltage tap	%	15.4	14.0
iv)	Tolerance on Impedance	%	As per IEC	
10.	Service		Outdoor	
11.	Duty		Continuous	

12.	Overload Capacity		IEC 60076-7 / IS 6600
13.	Temperature rise over 50 deg C Ambient Temp		
i)	Top oil measured by thermometer	O C	50
ii)	Average winding measured by resistance method	O C	55
iii)	Winding hot spot	O C	66
14.	Tank Hotspot Temperature	O C	95
15.	Windings		
i)	Lightning Impulse withstand Voltage		
	HV	kVp	950
	IV	kVp	650
	LV	kVp	250
	Neutral	kVp	95
ii)	Switching Impulse withstand Voltage		
	HV	kVp	750
iii)	One Minute Power Frequency withstand Voltage		
	HV	kVrms	395
	IV	kVrms	275
	LV	kVrms	95
	Neutral	kVrms	38
iv)	Neutral Grounding		Solidly grounded
v)	Insulation		
	HV		Graded
	IV		Graded
	LV		Uniform
vi)	Tertiary Connection		Delta
vii)	Tan delta of winding	%	≤0.5%
16.	Vector Group (3 –ph) (unless specified differently elsewhere)		YNa0d11

17.	Tap Changer		OLTC
i)	Tap Range and no. of steps		–5% to +10% of HV variation in the step of 1.25%, 12Steps
ii)	Location of Tap changer		On the 132 kV side of the series winding
iii)	Design		Constant flux voltage variation type as per cl. 6.2of IEC 60076 part-I
iv)	Tap control		Full capacity - on load tap changer suitable for group / independent, remote /local electrical and local manual operation and bi-directional power flow
18.	Bushings		
i)	Rated voltage		
	HV	kV	245
	IV	kV	145
	LV	kV	**72.5**
	Neutral	kV	36
ii)	Rated current (Min.)		
	HV	A	1250
	IV	A	1250
	LV	A	**1250**
	Neutral	A	**2000**
iii)	Lightning Impulse withstand Voltage		
	HV	kVp	1050
	IV	kVp	650
	LV	kVp	325
	Neutral	kVp	170
iv)	Switching Impulse withstand Voltage		
	HV	kVp	850

v)	One Minute Power Frequency withstand Voltage		
	HV	kVrms	505
	IV	kVrms	305
	LV	kVrms	155
	Neutral	kVrms	77
vi)	Minimum total creepagedistances		
	HV	mm	7595
	IV	mm	4495
	LV	mm	2248
	Neutral	mm	1116
viii)	Max Partial discharge level at Um		
	HV	pC	10
	IV	pC	10
	LV	pC	10
19.	Max Partial discharge level at 1.5 *Um/√3	pC	100
20.	Max Noise level at rated voltage and at principal tap at no load and all cooling active	dB	75
21.	Maximum Permissible Losses of Transformers		160 MVA
i)	Max. No Load Loss at rated voltage and frequency	kW	30
ii)	Max. Load Loss at rated current and at 75O C for HV and IV windings	kW	200
iii)	Max. I2R Loss at rated current and at 75O C for HV and IV windings	kW	145
iv)	Max. Auxiliary Loss at rated voltage and frequency	kW	6

Notes:

1) For parallel operation with existing transformer, the impedance, OLTC connection &range and the winding configuration (if necessary) is to be matched.
2) No external or internal Transformers are to be used to achieve the specified HV/IV, HV/LV and IV/LV impedances.
3) Tan delta of Winding & Bushing shall be measured at ambient temperature. No temperature correction factor shall be applied.

4) The criteria for Transformer losses shall be "**Copper Loss (Load Loss) > Iron Loss (No-load Loss) > Cooler Loss (Auxiliary Loss)".**
5) External minimum clearances in air for Phase to Phase and Phase to Earth shall be provided as per IS 2026 (Part 3)/IEC60076-3

ANNEXURE – A 3.0

Technical Particulars/Parameters
(132/33 KV, 3-Phase Transformer)

S. No.	Description	Unit	TECHNICAL PARAMETERS		
7.1	Voltage ratio (Line-to-Line)	kV	132/33		
7.2	Rated capacity (HV and LV)	MVA	80	50	31.5
7.3	No of phases		3 (Three)		
7.4	Vector Group		YNynO		
7.5	Type of transformer		Power Transformer		
7.6	Applicable Standard		IEC 60076 / IS 2026		
7.7	Cooling type		ONAN/ONAF		
7.8	Rating at different cooling	%	60 / 100		
7.9	Cooler Bank Arrangement		2 X 50%		
7.10	Frequency	Hz	50		
7.11	Tap changer				
i)	Type		On-load tap changer (CFVV)		
ii)	Tapping range and steps		-15% to +5% in steps of 1.25% for HV variation		
iii)	Location of tap changer		On HV neutral end		
7.12	HV-LV Impedance at 75 °C, at highest MVA base				
i)	Max. Voltage tap	%	13.2		
ii)	Principal tap	%	12.5		
iii)	Min. Voltage tap	%	11.8		
7.13	Tolerance on Impedance	%	As per IEC		
7.14	Service		Outdoor		
7.15	Duty		Continuous		
7.16	Overload Capacity		IEC 60076-7		
7.17	Temperature rise over 50°C ambient temp.				
i)	Top oil measured by thermometer	^{O}C	45		

ii)	Average winding measured by resistance method	^{O}C	50
7.18	Winding hot spot rise over yearly weighted temperature of 32 ^{O}C		61
7.19	Tank hot spot temperature		110
7.20	Maximum design ambienttemperature	^{O}C	50
7.21	Windings		
i)	Lightning Impulse withstand Voltage		
	HV	kVp	650
	LV	kVp	170
	HV Neutral	kVp	95
	LV Neutral	kVp	170
ii)	Chopped Wave Lightning Impulse Withstand Voltage		
	HV	kVp	715
	LV	kVp	187
iii)	Switching Impulse withstand Voltage		
	HV	kVp	540
iv)	One Minute Power Frequency withstand Voltage		
	HV	kVrms	275
	LV	kVrms	70
	HV Neutral	kVp	38
	LV Neutral	kVp	70
v)	Neutral Grounding (HV and LV)		Solidly grounded
vi)	Insulation		
	HV		Graded
	LV		Uniform
vii)	Tan delta of winding	%	≤0.5%
7.22	Bushings		
i)	Rated voltage		
	HV	kV	145
	LV, LV Neutral & HV Neutral	kV	36
ii)	Rated current (Min.)		
	HV	A	1250
	LV	A	1250 for (50 & 31.5MVA) 2000 (for 80MVA)
	HV Neutral & LV Neutral	A	1250
iii)	Lightning Impulse withstand		

	Voltage				
	HV	kVp	650		
	LV, HV Neutral and LV Neutral	kVp	170		
iv)	One Minute Power Frequency withstand Voltage				
	HV	kVrms	305		
	LV, HV Neutral and LV Neutral	kVrms	77		
v)	Minimum total creepage distances		(Specific creepage distance: 31mm/kV corresponding to the line to line highest system voltage)		
	HV	Mm	4495		
	LV, HV Neutral and LV Neutral	Mm	1116		
vi)	Max Partial discharge level at Um on HV	pC	10		
7.23	Max Partial discharge level at 1.58*Ur/√3	pC	100		
7.24	Max Noise level at rated voltage, principal tap & no load and all cooling active	dB	75 for 80MVA & 50MVA 70 for 31.5MVA		
7.25	**Maximum Permissible Losses of Transformers**		**80MVA**	**50 MVA**	**31.5 MVA**
i)	**Max. No Load Loss at rated voltage and frequency**	kW	**35**	**25**	**18**
ii)	**Max. Load Loss at rated current and frequency and at 75O C at principal tap between HV & LV**	kW	**200**	**125**	**110**
iii)	**Max. I2R Loss at rated current and frequency and at 75O C at principal tap between HV & LV**	kW	**170**	**105**	**93.5**
iv)	**Max. Auxiliary Loss at rated voltage and frequency**	kW	**5**	**3**	**2**

<u>Notes:</u>

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

5. External minimum clearances in air for Phase to Phase and Phase to Earth shall be provided as per IS 2026 (Part 3) / IEC60076-3

ANNEXURE – A 4.0

Technical Particulars/Parameters (220/33 KV, 100 MVA 3-Phase Transformer)

Cl. No.	Description	Unit	Technical Parameters
6.1	Voltage ratio (Line-to-Line)	kV	220/33
6.2	Rated Capacity		
	HV	MVA	100
	LV	MVA	100
6.3	No of phases		3 (Three)
6.4	Vector Group		YNyn0
6.5	Type of transformer		Power transformer
6.6	Applicable Standard		IEC 60076 / IS 2026
6.7	Cooling type		ONAN / ONAF / OFAF or ONAN/ONAF/ODAF
6.8	Rating at different cooling	%	60 / 80 / 100
6.9	Frequency	Hz	50
6.10	Cooler Bank Arrangement		2 X 50%
6.11	Tap Changer		
i)	Type		On-load tap changer
ii)	Tap range and steps		-15% to +5% in steps of 1.25% for HV variation
iii)	Location of tap changer		On HV neutral end
6.12	Impedance at 75°C, at highest MVA Base		
i)	Max. Voltage tap	%	16.2
ii)	Principal tap	%	15.0
iii)	Min. Voltage tap	%	14.0
iv)	Tolerance on Impedance		As per IEC
6.13	Service		Outdoor
6.14	Duty		Continuous
6.15	Overload Capacity		IEC-60076-7
6.16	Temperature rise over 50 deg C ambient Temp		
i)	Top oil measured by thermometer	^{O}C	45
ii)	Average winding measured by resistance method	^{O}C	50
6.17	Winding hot spot rise over yearly weighted temperature of 32 ^{O}C	^{O}C	61
6.18	Tank Hotspot Temperature	^{O}C	110
6.19	Maximum design ambient temperature	^{O}C	50

6.20	Windings		
i)	Lightning Impulse withstand Voltage		
	HV	kVp	950
	LV	kVp	170
	HV Neutral	kVp	95
	LV neutral	kVp	170
ii)	Chopped Wave Lightning Impulse Withstand Voltage		
	HV	kVp	1045
	LV	kVp	187
iii)	Switching Impulse withstand Voltage		
	HV	kVp	750
iv)	One Minute Power Frequency withstand Voltage		
	HV	kVrms	395
	LV	kVrms	70
	HV Neutral	kVrms	38
	LV neutral		70
v)	Neutral Grounding (HV & LV)		Solidly grounded
vi)	Insulation		
	HV		Graded
	LV		Uniform
vii)	Tan delta of winding	%	≤ 0.5
6.21	Bushing		
i)	Rated voltage		
	HV	kV	245
	LV	kV	36
	HV Neutral	kV	36
	LV Neutral		
ii)	Rated current		
	HV	A	1250
	LV	A	3150
	HV Neutral	A	3150
	LV neutral		3150
iii)	Lightning Impulse withstand Voltage		
	HV	kVp	1050
	LV	kVp	170
	HV Neutral	kVp	170
	LV neutral	kVp	170
iv)	Switching Impulse withstand Voltage		
	HV	kVp	850
v)	One Minute Power Frequency withstand Voltage		
	HV	kVrms	505
	LV	kVrms	77
	Neutral	kVrms	77
vi)	Minimum total creepage distances		(Specific creepage distance:

			31mm/kV corresponding to the line to line highest system voltage)
	HV bushing	mm	7595
	LV bushing	mm	1116
	HV neutral / LV neutral	mm	1116
vii)	Max Partial discharge level at Um		
	HV	pC	10
6.22	Max Partial discharge level at 1.58 * Ur / √3	pC	100
6.23	Max Noise level at rated voltage, principal tap & no load and all cooling active	dB	80
6.24	**Maximum Permissible Losses of Transformers**		
i)	Max. No Load Loss at rated voltage and frequency	kW	43
ii)	Max. Load Loss at rated current and at 75°C for HV and LV windings at principal tap position	kW	245
iii)	Max. I2R Loss at rated current and at 75° C for HV and LV windings at principal tap position	kW	200
iv)	Max. Auxiliary Loss at rated voltage and frequency	kW	5

Notes:

1. For parallel operation with existing transformer, percentage impedance, OLTC connection & range, vector group and the winding configuration (if necessary) is to be matched.
2. No external or internal Transformers are to be used to achieve the specified HV/IV, HV/LV and IV/LV impedances.
3. Tan delta of Winding & Bushing shall be measured at ambient temperature. No temperature correction factor shall be applied.
4. The criteria for Transformer losses shall be "**Copper Loss (Load Loss) > Iron Loss (No Load Loss) > Cooler Loss (Auxiliary Loss)".**
5. External minimum clearances in air for Phase to Phase and Phase to Earth shall be provided as per IS 2026 (Part 3) / IEC60076-3

Annexure–B
Design Review Document

Sr. No.	Description
1.	Core and Magnetic Design
2.	Over-fluxing characteristics upto 1.7U_m
3.	Inrush-current characteristics while charging from HV & IV respectively.
4.	Winding and tapping design

5.	Short-circuit withstand capability including thermal stress for min. 2 Sec.
6.	Thermal design including review of localised potentially hot area.
7.	Cooling design
8.	Overload capability
9.	Eddy current losses
10.	Seismic design, as applicable
11.	Insulation co-ordination
12.	Tank and accessories
13.	Bushings
14.	Tap changers
15.	Protective devices
16.	Fans, pumps and radiators
17.	Sensors and protective devices– its location, fitment, securing and level of redundancy
18.	Oil and oil preservation system
19.	Corrosion protection
20.	Electrical and physical Interfaces with substation
21.	Earthing (Internal & External)
22.	Processing and assembly
23.	Testing capabilities
24.	Inspection and test plan
25.	Transport and storage
26.	Sensitivity of design to specified parameters
27.	Acoustic Noise
28.	Spares, inter-changeability and standardization
29.	Maintainability
30.	PRD and SPR (number & locations)
31.	Conservator capacity calculation
32.	Winding Clamping arrangement details with provisions for taking it “in or out of tank”
33.	Conductor insulation paper details
34.	The design of all current connections
35.	Location & size of the Valves

Annexure-C

UNDERTAKING

We, M/s. -------------------------- , have participated in Tender No. ----------------------- for supply of:

1) -------- kV class -------- MVA Auto/Power Transformers

2) -------- kV class --------- MVA Auto/Power Transformers

3) -------- kV class --------- MVA Auto/Power Transformers

4) -------- kV class --------- MVA Auto/Power Transformers

to AEGCL.

In accordance with the terms of the said tender, we hereby undertake that we shall use imported prime CRGO steel lamination and not the second grade CRGO steel lamination for the manufacturing of the transformers against this Tender. Further, we shall produce the following documents at the time of inspection of transformers:

a) Invoice of supplier
b) Mill's Test Certificate issued by Customs
c) Packing list
d) Bill of lading
e) Bill of entry Certificate issued by Customs.

Signature of the Tenderer :

Name :

Designation :

Seal of the Company :

(On Rs 100/- stamp paper duly notarized)

Annexure – D
Painting Procedure

PAINTING	**Surface Preparation**	**Primer coat**	**Intermediate undercoat**	**Finish coat**	**Total dry film thick-ness (DFT)**	**Colour shade**
Main tank, pipes, conservator tank, oil storage tank& DM Box 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,	Shot Blast	Hot oil	--	--	Minimum	Glossy

pipes (above 80 NB), conservator tank, oil storage tank & DM Box etc. (Internal surfaces)	cleaning Sa 2 ½*	proof, low viscosity varnish or Hot oil resistant, non-corrosive Paint			30µm	white for paint
Radiator (external surfaces)	Chemical / Shot Blast cleaning Sa 2 ½*	Epoxy base Zinc primer (30-40µm)	Epoxy base Zinc primer (30-40µm)	PU paint (Minimum 50µm)	Minimum 100µm	Matching shade of tank/ different shade aesthetically matching to tank
	contractor may also offer Radiators with hot dip galvanised in place of painting with minimum thickness of 40µm (min)					
Radiator and pipes up to 80 NB (Internal surfaces)	Chemical cleaning, if required	Hot oil proof, low viscosity varnish or Hot oil resistant, non-corrosive Paint	--	--	--	--
Digital RTCC Panel	Seven tank process as per IS:3618	Zinc chromate Primer	--	EPOXY paint with PU top coat or POWDER	Minimum 80µm / for powder coated	RAL 7035 shade for exterior and Glossy
	& IS:6005	(two coats)		coated	minimum 100µm	white for interior

Control cabinet	/ Marshalling	Box - No painting is required.

Note: (*) Indicates Sa 2 ½ as per Swedish Standard SIS 055900 of ISO 8501 Part-1.

Annexure- F

RATING & DIAGRAM PLATE

The transformer shall be provided with a rating plate of weatherproof material, fitted in a visible position, showing the appropriate items indicated below. The entries on the plate shall be in English in indelibly marked.

Minimum Information to be provided on the plate:

Manufacturer's name, country and city where the transformer was assembled					
MVA Rating, Voltage ratio, Type of transformer (for example 315MVA 400/220/33kV Auto Transformer)					
Type of Cooling			Applicable Standard		
Rated Power at different cooling			Rated frequency	Hz	
HV/IV	MVA	--/-- /--	Number of phases		
LV	MVA		% Impedance / Ohmic Impedance		
Rated Voltage			(a) HV-IV		
HV	kV		Min. tap	%	
IV	kV		Principal Tap	%	
LV	kV		Max. Tap	%	
Rated Current			(b) HV-LV	%	
HV	A		(c) IV-LV	%	
IV	A		Vector Group		
LV	A		Core mass	kg	
Rated Thermal Short Circuit withstand	kA (sec)		Copper Mass		
capability Current and Duration					
Basic Insulation Level (Lightening Impulse/Switching Impulse/Power Frequency Withstand Voltage)			(a) HV	Kg	
HV	kVp/ kVp/ kVrms		(b) IV	Kg	
IV	kVp/ kVp/ kVrms		(c) LV	Kg	

LV	kVp/ kVp/ kVrms		(d) Regulating	Kg	
Neutral	kVp/ kVp/ kVrms		Core & Coil Mass	Kg	
Guaranteed Temperature rise over ambient temperature of 50 Deg. C			Transportation Mass	Kg	
(a) Top Oil	0C		Tank & Fitting mass		
(b) Winding	0C		Type & total mass of insulating oil	Kg	
Vacuum withstand Capability of the tank	mm of Hg		Total mass	Kg	
OLTC make and rating (current & Voltage class)			Quantity of oil in OLTC	Ltrs	
Noise level at rated voltage and at principal tap	dB		Transformer oil Quantity	Ltrs	
Tan delta ofwinding			Paint Shade		
Moisture content	ppm		No load loss at rated voltage & frequency	KW	
Manufacturer's Serial number			Load loss at rated current & frequency (at 75^0C) for HV & IV/LVwinding	KW	
Year of manufacture			I^2R loss at rated current & frequency (at 75^0C) for HV & IV/LV winding	KW	
Work Order No.			Auxiliary loss at rated voltage & frequency	KW	

Purchaser's Order No. & Date					
OGA Drg. No.					
Vector Group Diagram					
Winding Connection diagram (Connection between all windings including tap windings, ratings of built-in current transformers, etc. shall be presented on the diagram)					
Table giving details of OLTC like tap position Nos. and corresponding tapping voltage, tapping current & connection between terminals for different tap positions etc.					
Details of Current Transformers (e.g. Bushing CTs, CT for WTI) installed in transformer like the location, core Nos., ratio(s), accuracy class, rated output (VA burden), knee point voltage, magnetizing current, maximum CT secondary resistance, terminal marking and application of the current transformer					
Warning: "Main conservator is fitted with an air cell"					
Tie-in-resistor has been used in OLTC (if applicable)					
Purchaser's Name					

When a transformer is intended for installation at high altitude, the altitude, power rating and temperature rise at that altitude shall be indicated on the nameplate.

Plates with identification and characteristics of auxiliary equipment according to standards for such components (bushings, tap-changers, current transformers, cooling equipment etc.) shall be provided on the components themselves.

Annexure- G

1.0 Bushing Current Transformer and Neutral Current Transformer Parameters (On each phase) for 3-ph, 500MVA 400/220/33 kV Transformers:

Description	Bushing Current Transformer Parameters (Transformer)		
	HV Side	IV Side	Neutral Side

Ratio			
CORE 1	1600/1	1600/1	1600/1
CORE 2	1000/1	1600/1	-
CORE 3	Refer to note 1		
Minimum knee point voltage or burden and accuracy class			
CORE 1	1600V, PX / PS	1600V, PX / PS	1600V, PX / PS
CORE 2	0.2S Class 20VA ISF≤5	0.2S Class 20VA ISF≤5	-
CORE 3	Refer to note 1		
Maximum CT Secondary Resistance			
CORE 1	4.0 Ohm	4.0 Ohm	4.0 Ohm
CORE 2	-	-	-
CORE 3	Refer to note 1		
Application			
CORE 1	Restricted Earth Fault	Restricted Earth Fault	Restricted Earth Fault
CORE 2	Metering	Metering	-
CORE 3	Refer to note 1		
Maximum magnetization current (at knee point voltage)			
CORE 1	25 mA	25 mA	25 mA
CORE 2	-	-	-
CORE 3	Refer to note 1		

Note:

i) **Parameters of WTI CT for each winding shall be provided by the contractor.**

ii) For estimation of spares, one set of CTs shall mean one CT of each type used in transformer.

iii) 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.

2.0 Technical Parameters of Bushing Current Transformers and Neutral Current Transformers for 160MVA 220/132 kV 3-Ph Transformers:

Description	**Bushing Current Transformer Parameters (Transformer)**		
	HV Side	**IV Side**	**Neutral Side**
(a) Ratio			
CORE 1	1000/1	1000/1	1000/1
CORE 2	600/1	1000/1	-
CORE 3	Refer to note 1		
(b) Minimum knee point voltage or burden and accuracy class			
CORE 1	600V, PX / PS	600V, PX / PS	600V, PX / PS
CORE 2	0.2S Class 15VA ISF ≤ 5	0.2S Class 15VA ISF ≤ 5	-
CORE 3	Refer to note 1		
(c) Maximum CT Secondary Resistance			
CORE 1	1.5 Ohm	1.5 Ohm	1.5 Ohm
CORE 2	-	-	-
CORE 3	Refer to note 1		
(d) Application			
CORE 1	Restricted Earth Fault	Restricted Earth Fault	Restricted Earth Fault
CORE 2	Metering	Metering	-
CORE 3	Refer to note 1		
(e) Maximum magnetization current (at knee point voltage)			
CORE 1	100 mA	100 mA	100 mA
CORE 2	-	-	-
CORE 3	Refer to note 1		

NOTE:

i) **Parameters of WTI CT for each winding shall be provided by the contractor.**
ii) For estimation of spares, one set of CTs shall mean one CT of each type used in transformer.
iii) 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.

3 Technical Parameters of Bushing Current Transformer and Neutral Current Transformer for 50 MVA 132/33 kV 3-Ph Transformers:

Description	**Bushing Current Transformer Parameters (Transformer)**			
	HV Side	**HV Neutral Side**	**LV Side**	**LV Neutral Side**
(a) Ratio				
CORE 1	300/1	300/1	1000/1	1000/1
CORE 2	300/1	300/1	1000/1	1000/1
CORE 3	Refer to note 1			
(b)Minimum knee point voltage or burden and accuracy class				
CORE 1	600V, PX / PS	600V, PX / PS	1000V, PX / PS	1000V, PX / PS
CORE 2	0.2S Class 15VA ISF ≤ 5	600V, PX / PS	0.2S Class 15VA ISF ≤ 5	1000V, PX / PS
CORE 3	Refer to note 1			
(c)Maximum	**CT Secondary Resistance**			
CORE 1	1.5 Ohm	1.5 Ohm	1.5 Ohm	1.5 Ohm
CORE 2	-	1.5 Ohm	-	1.5 Ohm
CORE 3	Refer to note 1			
(d) Application				
CORE 1	Restricted Earth Fault	Restricted Earth Fault	Restricted Earth Fault	Restricted Earth Fault
CORE 2	Metering	Restricted Earth fault	Metering	Restricted Earth Fault
CORE 3	Refer to note 1			
(e)Maximum	**magnetization current (at knee point voltage)**			

CORE 1	100 mA	100 mA	100 mA	100 mA
CORE 2	-	100 mA	-	100 mA
CORE 3	Refer to note 1			

NOTE:

i) **Parameters of WTI CT for each winding shall be provided by the contractor.**
ii) For estimation of spares, one set of CTs shall mean one CT of each type used in transformer.
iii) 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.

5.0 Technical Parameters of Bushing Current Transformer and Neutral Current Transformer for 100 MVA 220/33 kV 3-Ph Transformers:

Description	**Bushing Current Transformer Parameters (Transformer)**			
	HV Side	**HV Neutral Side**	**LV Side**	**LV Neutral Side**
(a) Ratio				
CORE 1	300/1	300/1	2000/1	2000/1
CORE 2	300/1	300/1	2000/1	2000/1
CORE 3	Refer to note 1			
(b)Minimum knee point voltage or burden and accuracy class				
CORE 1	600V, PX / PS	600V, PX / PS	2000V, PX / PS	2000V, PX / PS
CORE 2	0.2S Class 15VA ISF ≤ 5	600V, PX / PS	0.2S Class 15VA ISF ≤ 5	2000V, PX / PS
CORE 3	Refer to note 1			
(c)Maximum CT Secondary Resistance				
CORE 1	1.5 Ohm	1.5 Ohm	1.5 Ohm	1.5 Ohm
CORE 2	-	1.5 Ohm	-	1.5 Ohm
CORE 3	Refer to note 1			
(d)Application				

CORE 1	Restricted Earth Fault	Restricted Earth Fault	Restricted Earth Fault	Restricted Earth Fault
CORE 2	Metering	Restricted Earth Fault	Metering Fault	Restricted Earth Fault
CORE 3	Refer to note 1			
(e)Maximum Magnetization current (at knee point voltage)				
CORE 1	100 mA	100 mA	100 mA	100 mA
CORE 2	-	100 mA	-	100 mA
CORE 3	Refer to note 1			

NOTE:

- **(i) Parameters of WTI CT for each winding shall be provided by the contractor.**
- (ii) For estimation of spares, one set of CTs shall mean one CT of each type used in transformer.
- (iii) 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.

Annexure- H

Test Procedures

General

Tests shall be carried out as per following procedure. However, IEC 60076 shall be followed in general for other tests. Manufacturer shall offer the transformer unit for type testing with all major fittings including radiator bank, Marshalling Box, Common Marshalling Box RTCC (as applicable) assembled.

1. Core assembly dielectric and earthing continuity test

After assembly each core shall be tested for 1 minute at 2000 Volts between all yoke clamps, side plates and structural steel work (core to frame, frame to tank & core to tank).

The insulation of core to tank, core to yoke clamp (frame) and yoke clamp (frame) to tank shall be able to withstand a voltage of 2 kV (DC) for 1 minute. Insulation resistance shall be minimum 1 GΩ for all cases mentioned above.

2. Measurement of winding resistance

After the transformer has been under liquid without excitation for at least 3 hr, the average liquid temperature shall be determined and the temperature of the winding shall be deemed to be the same as the average liquid temperature. The average liquid temperature is taken as the mean of the top and bottom liquid temperatures. Measurement of all the windings including compensating (in case terminal is available at outside) at normal and extreme taps.

In measuring the cold resistance for the purpose of temperature-rise determination, special efforts shall be made to determine the average winding temperature accurately. Thus, the difference in temperature between the top and bottom liquid shall not exceed 5 K. To obtain this result more rapidly, the liquid may be circulated by a pump.

3. No-load loss and current measurement

As per IEC 60076-1:2011 clause 11.5

4. Measurement of short-circuit impedance and load loss

The short-circuit impedance and load loss for a pair of windings shall be measured at rated current & frequency with voltage applied to the terminals of one winding, with the terminals of the other winding short-circuited, and with possible other windings open- circuited. The difference in temperature between the top and bottom liquid shall not exceed 5 K. To obtain this result more rapidly, the liquid may be circulated by a pump. Loss measurement for all combinations (HV-IV, HV-LV, IV-LV and at Normal and extreme taps).

5. Short term heat run test (Not Applicable for unit on which temperature rise test is performed)

In addition to the type test for temperature rise conducted on one unit, each cooling combination shall routinely be subjected to a short-term heat run test to confirm the performance of the cooling system and the absence of manufacturing defect such as major oil flow leaks that may bypass the windings or core. DGA samples shall be taken at intervals to confirm the gas evolution.

For ODAF or OFAF cooling, the short term heat run test shall be done with the minimum number of pumps for full load operation in order to shorten the temperature build up. Each short term heat run test is nevertheless expected to take about 3 hours.

For ODAF or OFAF cooled transformers an appropriate cross check shall be performed to prove the effective oil flow through the windings. For this purpose, the effect on the temperature decay by switching the pumps off/ on at the end of the heat run should demonstrate the effectiveness of the additional oil flow. Refer to SC 12, 1984 CIGRE 1984 SC12-13 paper by Dam, Felber, Preiniger et al.

Short term heat run test may be carried out with the following sequence:

- Heat run test with pumps running but oil not through coolers.
- Raise temperature to 5 deg less than the value measured during temperature rise test.
- Stop power input and pumps for 6 minutes and observe cooling down trend
- Restart pumps and observe increased cooling trend due to forced oil flow

This test is applicable for the Transformer without Pump also (ONAN or ONAF rating). For such type of transformer test may be carried out with the following sequence:

Arrangement shall be required with pump of suitable capacity (considering the oil velocity) without cooler bank. Raise the oil temperature 20-25 deg C above ambient. Stop power input and pumps for 6 minutes and observe cooling down trend. Restart pumps and observe increased cooling trend due to forced oil flow.

6. Temp. Rise Test as per IEC: 60076

Gas chromatographic analysis on oil shall also be conducted before, during and after this test and the values shall be recorded in the test report. The sampling shall be in accordance with IEC 60567.

The temperature rise test shall be conducted at a tap for the worst combination of loading (3-Winding Loss) for the Top oil of the transformer.

3-Winding Loss = HV (Max MVA) + IV (Max MVA) + LV (Max MVA).

The Contractor before carrying out such test shall submit detailed calculations showing losses on various taps and for the three types of ratings of the transformer and shall recommend the combination that results in highest temperature rise for the test.

The Temperature rise type test results shall serve as a “finger print” for the units to be tested only with short term heat run test.

Gas chromatographic analysis on oil shall also be conducted before, during and after this test and the values shall be recorded in the test report. The sampling shall be in accordance with IEC 60567.

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. Keep the pumps running for 2 hours before and after the heat run test. Take oil samples during this period. For ONAN/ONAF cooled transformers, sample shall not be taken earlier than 2 hours after shut down. The acceptance norms with reference to various gas generation rates shall be as per IEC 61181.

The DGA results shall generally conform to IEC/IEEE/CIGRE guidelines.

i. Test conditions for temperature rise test:

- This test shall be generally carried out in accordance with IEC 60076-2
- For each cooling combination with cooler bank, tests shall be done on the maximum current tap for a minimum of 12 hours for ONAN/ONAF and 24 hours for ODAF or OFAF or ONAF2 with saturated temperature for at least 4 hours while the appropriate power and current for core and load losses are supplied.
- The total testing time, including ONAN heating up period, steady period and winding resistance measurements is expected to be about 48 hours.
- DGA tests shall be performed before and after heat run test and DGA results shall generally conform to IEC/IEEE/CIGRE guidelines.

ii. Test records:

Full details of the test arrangements, procedures and conditions shall be furnished with the test certificates and shall include at least the following.

iii. General:

- Purchaser's order number and transformer site designation.
- Manufacturer's name and transformer serial number.
- Rating of transformer
- MVA
- Voltages and tapping range
- Number of phases
- Frequency
- Rated currents for each winding
- Vector Group
- Cooling Type
- Measured no-load losses and load losses at 75° C.
- Altitude of test bay.
- Designation of terminals supplied and terminals strapped.

iv. Top oil temperature rise test:

A log of the following quantities taken at a minimum of 30-minute intervals:

- Time
- Voltage between phases

- Current in each phase and total power
- Power in each phase and total power
- Ambient temperature
- Top oil temperature
- Cooler inlet and outlet oil temperatures
- Hot spot temperatures (make use of probes) (if applicable)
- Colour photographs of the four sides and top of the transformer together with the corresponding series of thermal images (colour) during starting of the test then after every four hours till the temperature stabilised and finally during temperature stabilised for each rating (ONAN/ONAF/OFAF).

Notes: The probes may be left in position provided the reliability and integrity of unit will not be jeopardized during its long-life expectancy.

v. Winding temperature rise test

- Record the 'cold' resistance of each winding and the simultaneous top oil and ambient air temperatures, together with the time required for the effect to disappear.
- Record the thermal time constant of the winding.
- Log the half-hourly readings of the quantities as for the top oil temperature rise test.
- Provide a table of readings, after shut-down of power, giving the following information;
  a) Time after shut- down:
  b) Time increment:
  c) Winding resistance: At least 20 minutes reading
  d) Resistance increment:
- Provide a record of all calculations, corrections and curves leading to the determination of the winding temperatures at the instant of shut-down of power.
- Record any action taken to remedy instability of the oil surge device during initiation of the oil circulating pumps.

Temperature measurements as per special probes or sensors (fibre optic) placed at various locations shall also be recorded.

7. Dielectric Tests

Following Test shall be performed in the sequence given below as per IEC 60076-3:2013 clause 7.2.3 shall be followed:

a) Lightning impulse tests (LIC, LIN)
b) Switching impulse (SI)
c) Applied voltage test (AV)
d) Line terminal AC withstand test (LTAC)
e) Induced voltage test with partial discharge measurement (IVPD)

8. Measurement of transferred surge on LV or Tertiary due to HV & IV Lightning impulse:

Following tests shall be carried out with applying 20% to 80% of rated Impulse & Switching impulse (upto 60% for IV, Sr. No. 7 & 8 of below table) voltage. Finally, measured value shall be extrapolated for 100% rated voltage.

Table for Transfer surge (Impulse) at Max, Nor. and Min. Voltage Tap

Sr. No.	Impulse Type	Voltage applied	Earthed Points	Open / not earthed point	Measurement Point
1	FW	1.1	2.1, N & 3.2	-	3.1
2	FW	1.1	2.1, N & 3.1	-	3.2
5	FW	2.1	1.1, N & 3.2	-	3.1
6	FW	2.1	1.1, N & 3.1	-	3.2

Similar tests to be conducted for switching surge transformer at Max, Nor. and Min. Voltage Tap.

Where 1.1 : HV Terminal
2.1 : IV Terminal
3.1 & 3.2 : LV or Tertiary Terminal

Acceptance criteria

Transfer surge at Tertiary should not exceed 250kVp at any conditions for 400kV Voltage class Transformer. For other transformer it shall be below the impulse level of LV winding.

9. Chopped wave & full wave lightning impulse test for the line terminals (LIC & LI) and Switching impulse test

Chopped wave lightning impulse and switching impulse test shall be performed at normal and extreme taps on Unit-1, Unit-2 and Unit-3 respectively for 1-Ph unit, otherwise R ph, Y Ph and B Ph respectively for 3-Ph unit. All the parameters as per IEC shall be mentioned in the report.

10. Measurement of power taken by fans and oil pumps (100 % cooler bank)

Losses of each fan and pumps including spare shall be measured at rated voltage and frequency. Fans and Pumps shall be mounted with cooler bank as per approved drawing during measurement. Serial No, applied voltage, measured current, frequency and make shall be furnished in the test report.

11. Tank Tests

i. Oil Leakage Test

All tanks and oil filled compartments shall be 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 subjected to a pressure equal to normal head of oil plus 35 kN/sq.m (5 psi) measured at the base of the tank. This pressure shall be maintained for a period of not less than 12 hours for oil and 1 hour for air during which no leakage shall occur.

ii. Vacuum Test

All transformer tanks 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. absolute (25 torr) for one hour. The permanent deflection of flat plate after the vacuum has been released shall not exceed the values specified below:

Horizontal Length (in mm)	Permanent deflection of flat plate (in mm)
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

iii. Pressure Test

All transformer tanks, its radiator, conservator and other fittings together or separately shall be subjected to a pressure corresponding to twice the normal head of oil or normal oil head pressure plus 35 KN/sq.m 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.

12. Dynamic short circuit withstand test shall be carried out as per IEC 60076-5. Dynamic short circuit test shall be carried out in HV-IV combination at nominal & extreme tap positions. For LV winding, dynamic short circuit shall be carried out either on HV-LV or IV-LV combination, whichever draws higher short circuit current as per calculation. Type tests shall be carried out before short circuit test. Following shall also be conducted before and after Short Circuit test:

i) Dissolved gas analysis
ii) Frequency response analysis
iii) All routine tests

Detail test procedure shall be submitted by contractor & shall be approved before short circuit test.

13. Routine test on bushings shall be done as per IEC 60137.

Annexure - I

Test Plan

No.	**Test**	**132 ≥ Um ≤ 170kV**	**U_m > 170kV**
1.	Measurement of winding resistance	Routine	Routine
2.	Voltage ratio measurement	Routine	Routine
3.	Polarity test	Routine	Routine
4.	No-load loss and current measurement	Routine	Routine
5.	Magnetic balance test (for three phase Transformer only)	Routine	Routine
6.	Impedance and load loss measurement	Routine	Routine
7.	Measurement of insulation resistance & Polarization Index	Routine	Routine
8.	Measurement of insulation power factor and capacitance between winding and earth and Bushings	Routine	Routine
9.	Full wave lightning impulse test for the line terminals (LI)	Routine	-
10.	Induced voltage withstand test (IVW)	Routine	-
11.	Applied voltage test (AV)	Routine	Routine
12.	Induced voltage test with PD measurement (IVPD)	Routine	Routine
13.	On-load tap changer test (Ten complete cycle before LV test)	Routine	Routine
14.	Gas-in-oil analysis	Routine	Routine
15.	Core assembly dielectric and earthing continuity test	Routine	Routine
16.	Oil leakage test on transformer tank	Routine	Routine
17.	Appearance, construction and dimension check	Routine	Routine
18.	Short duration heat run test (Not Applicable for unit on which temperature rise test is performed)	Routine	Routine
19.	Measurement of no load current & Short circuit Impedance with	Routine	Routine

	415 V, 50 Hz AC.		
20	Frequency Response analysis (Soft copy of test report to be	Routine	Routine
	submitted to site along with test reports)		
21.	High voltage with stand test on auxiliary equipment and wiring after Assembly	Routine	Routine
22.	Tank vacuum test	Routine	Routine
23.	Tank pressure test	Routine	Routine
24.	Chopped wave lightning impulse test for the line terminals (LIC)	Type	Routine
25.	Switching impulse test for the line terminal (SI)	Type	Routine
26	Line terminal AC withstand voltage test (LTAC)	Routine	Type
27.	Measurement of transferred surge on LV or Tertiary as applicable due to HV lightning impulse and IV lighting impulse (as applicable)	Type	Type
28.	Lightning impulse test for the neutral terminals (LIN)	Type	Type
29.	Temperature rise test	Type	Type
30.	Measurement of Zero seq. reactance (for three phase Transformer only)	Type	Type
31.	Measurement of harmonic level in no load current	Type	Type
32.	Measurement of acoustic noise level	Type	Type
33.	Measurement of power taken by fans and oil pumps (Not applicable for ONAN)	Type	Type
34.	Dynamic Short circuit withstand test	Type	Type

ANNEXURE J

PT 100 Resistance (Temperature Vs Resistance)
(BS 1904: 1984 & IEC 751: 1985)

TEMP °C	RESISTANCE (OHMS)		
	LOW	NOMINAL	HIGH
0	99.88	100.00	100.12
10	103.76	103.90	104.04
20	107.63	107.79	107.95
30	111.49	111.67	111.85
40	115.35	115.54	115.73
50	119.19	119.40	119.61
60	123.01	123.24	123.47
70	126.82	127.07	127.32
80	130.62	130.89	131.16
90	134.42	134.70	134.98
100	138.20	138.50	138.80
110	141.97	142.29	142.61
120	145.72	146.06	146.40
130	149.46	149.82	150.18
140	153.21	153.58	153.95
150	156.92	157.31	157.70

PT 100 (Temperature Vs Output Signal)
Temperature Range: 0 - 150 ^{O}c
Signal Range: 4-20 mA

TEMPERATURE °C	NOMINAL RESISTANCE (OHMS)	OUTPUT SIGNAL RANGE (4 - 20mA)		
		LOW	NOMINAL	HIGH
0	100.00	3.800	4.000	4.200
10	103.90	4.867	5.067	5.267
20	107.79	5.933	6.133	6.333
30	111.67	7.000	7.200	7.400
40	115.54	8.066	8.266	8.466
50	119.40	9.133	9.333	9.533
60	123.24	10.200	10.400	10.600
70	127.07	11.266	11.466	11.666
80	130.89	12.333	12.533	12.733
90	134.70	13.399	13.599	13.799
100	138.50	14.466	14.666	14.866
110	142.29	15.533	15.733	15.933
120	146.06	16.599	16.799	16.999
130	149.82	17.666	17.866	18.066
140	153.58	18.732	18.932	19.132
150	157.31	19.800	20.000	20.200

ANNEXURE - K

Online Dissolved Gas (Multi-gas) and Moisture Analyser

1.1. Online Dissolved Gas (Multi-gas) and Moisture Analyser along with all required accessories including inbuilt display shall be provided with each Transformer for measurement & analysis of dissolved gases and moisture in the oil. Interpretations shall be as per IEC 60599-1999.

1.2. The equipment shall detect, measure and analyse the following gases:

Gases & Moisture Parameters	Typical Detection Range
H_2	5 – 5,000 ppm
CH_4	5 – 5,000 ppm
C_2H_6	5 – 5,000 ppm
C_2H_4	3 – 5,000 ppm
C_2H_2	1 – 3,000 ppm
CO	10 – 10,000 ppm
CO_2	20 – 30,000 ppm
H_2O	2 – 100 % RS should have facility for measurement of moisture in oil in ppm

1.3. The analyser should measure (not calculate) all above gases and should have 100% sensitivity. The equipment shall be capable of transferring data to sub-station automation system confirming to IEC 61850. Necessary interface arrangement shall be provided by the contractor for integration with automation system. The necessary type test report for such confirmation shall be submitted during detailed engineering.

1.4. Equipment shall have facility to give SMS alert to at least three users whenever any fault gas violates the predefined limit.

1.5. Equipment should work on station auxiliary supply. In case other supply is required for the equipment then suitable converter shall be included. All the necessary power and control cables, communication cables, cable accessories as required shall be provided by the supplier.

1.6. Online DGA shall be installed out door on Transformer in harsh ambient and noisy condition (Electromagnetic induction, Corona, and capacitive coupling). Equipment shall be mounted separately on ground. Suitable arrangement shall be provided to support and protect the inlet and outlet piping arrangement. The connecting oil lines must be of Stainless-Steel rigid pipes or flexible hoses. The equipment shall be suitable for proper operation in EHV substation (800kV) environment where switching takes place in the EHV/HV System. The suitable indications for power On, Alarm, Caution, normal operation etc. shall be provided on the front panel of the equipment. The equipment shall have IP55 Stainless Steel enclosure, suitable for 55 ^{0}C ambient temperature and EMI and EMC compatibility. The Equipment must carry a minimum of five (5) years manufacturer's Warranty.

1.7. The equipment shall display all the individual gas and moisture concentration on its display unit and shall have facility to download all the stored the data from the unit for further analysis. The sampling rate shall be selectable as 2 or 4 or 6 or 12 hours etc. The equipment shall have inbuilt memory to store these results for complete one year even if sampling is done at the lowest interval. The carrier and calibration gas (if applicable) shall have minimum capacity to work for at least three years without replacement. All the consumable (if any) upto warrantee period shall be included in the scope of supply.

1.8. The Equipment must have an automatic Calibration facility at fixed intervals. For calibration if anything required including cylinder must be mounted with the Equipment.

1.9. The technical feature of the equipment shall be as under:

Accuracy	+ 10%
Repeatability	+3% to 10% depending upon gases
Oil temperature range	- 20^0 C to + 120^0 C
External Temp. Range	- 20^0 C to + 55^0 C (External temp range of 55^0 C is important and should not be compromise due to Indian ambient & operating conditions.)
Humidity range	10 to 95 %
Operating Voltage	230 Vac; 50 Hz (±20% variation)
Communications	USB&IEC 61850 compliant

1.10. Software for fault indication and fault diagnostics shall include following:

Fault indication:

i) IEEE, IEC or user configurable levels of dissolved gases
ii) Rate of change trending

Fault Diagnosis:

i) Key gases
ii) Ratios (Rogers, IEC. etc.)
iii) Duval’s Triangle

1.11. The equipment shall be supplied with all necessary accessories required for carrying out DGA of oil sample complete in all respect as per the technical specification. The following shall be also form a part of supply.

i) Software
ii) Operation Manual (2 set for every unit),
iii) Software Manual and
iv) Compact disc giving operation procedures of Maintenance Manual & Trouble shooting instructions.

1.12. The installation and commissioning at site shall be done under the supervision of OEM representative or OEM certified representative.

1.13. The equipment shall be covered on warranty for a period of 5 years from the last date of complete commissioning and taking over the test set up. During this period, if the kit needs to be shifted to suppliers works for repairs, supplier will have to bear the cost of, spares, software, transportation etc. of kit for repair at test lab/works. Further supplier shall make alternate arrangement for smooth operation of the transformer.

Annexure - L

LIST OF TESTING EQUIPMENT

Sr. No.	Testing Equipment	Make & Model *
1	Automatic Transformer Oil BDV Testing Kit	DTA-100C (BAUR), OTS100AF-UKU-PX (Megger)
2	Oil Storage Tank (With Wheels)- 20kL Capacity	VPI / CEE DEE VACUUM / SICORP
3	Stainless Steel Oil sampling bottle (One Litre Capacity)	SCIENO TECH 1 litre
4	Syringes for sampling oil	Tomopol (Industrial Grade)

**** Bidder may offer equivalent or superior testing equipment.***

ANNEXURE - M

1.1 KV GRADE POWER & CONTROL CABLES

1.1 All Power & Control cables shall be supplied from reputed vendors.

1.2 Separate cables shall be used for AC & DC.

1.2 Separate cables shall be used for DC1 & DC2.

1.3 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.

1.4 The Aluminium/Copper wires used for manufacturing the cables shall be true circular in shape before stranding and shall be uniformly good quality, free from defects. All aluminium used in the cables shall be of H2 grade.

1.5 The fillers and inner sheath shall be of non-hygroscopic, fire-retardant material, shall be softer than insulation and outer sheath shall be suitable for the operating temperature of the cable.

1.6 Progressive sequential marking of the length of cable in metres at every one metre shall be provided on the outer sheath of all cables.

1.7 Strip wire armouring method (a) mentioned in Table 5, Page-6 of IS: 1554 (Part 1) – 1988 shall not be accepted for any of the cables. For control cables only round wire armouring shall be used.

1.8 The cables shall have outer sheath of a material with an oxygen index of not less than 29 and a temperature index of not less than 250°C.

1.9 All the cables shall conform to fire resistance test as per IS: 1554 (Part - I).

1.10 The normal current rating of all PVC insulated cables shall be as per IS: 3961.

1.11 Repaired cables shall not be accepted.

1.12 Allowable tolerance on the overall diameter of the cables shall be plus or minus 2 mm.

1.13 **PVC Power Cables**

1.13.1 The PVC (70°C) insulated 1100V grade power cables s hall be of FR type, C1 category, conforming to IS: 1554 (Part-I) and its amendments read along with this specification and shall be suitable for a steady conductor temperature of 70°C. The conductor shall be stranded aluminium. The Insulation shall be extruded PVC to type-A of IS: 5831. A distinct inner sheath shall be provided in all multi core cables. For multi core armoured cables, the inner sheath shall be of extruded PVC. The outer sheath shall be extruded PVC to Type ST-1 of IS: 5831 for all cables. The contractor can used copper cable of required size.

1.14 **PVC Control Cables**

1.14.1 The 1100V grade control cables shall be of FR type C1 category conforming to IS: 1554 (Part-1) and its amendments, read along with this specification. The conductor shall be stranded copper. The insulation shall be extruded PVC to type A of IS: 5831. A distinct inner sheath shall be provided in all cables whether armoured or not. The over sheath shall be extruded PVC to type ST-1 of IS: 5831 and shall be grey in colour except where specifically advised by the Employer to be black.

1.14.2 Cores shall be identified as per IS: 1554 (Part-1) for the cables up to five (5) cores and for cables with more than five (5) cores the identification of cores shall be done by printing legible Hindu Arabic Numerals on all cores as per clause 10.3 of IS: 1554 (Part - 1).

STANDARD TECHNICAL DATA SHEET (1.1kV GRADE XLPE POWER CABLES)

Sr. No	Description	Parameters	
1a	Cable Sizes	1 C x 630	3½ C x 300
b	Manufacturer's type designation	A2XWaY	A2XWY
2	Applicable standard	IS: 7098/PT-I/1988 & its referred Specifications	
3	Rated Voltage(volts)	1100 V Grade	
4	Type & Category	FR & C1	FR & C1
5	Suitable for earthed or unearthed system	for both	
6	Continuous current rating when laid in air in a ambient temp. of 50°C and for maximum conductor temp. of 70 °C of PVC Cables[For information only]	732	410
7	Rating factors applicable to the current ratings forvarious conditions of installation	As per IS-3961-Pt-II-67	
8	Short circuit Capacity		
a	Guaranteed Short Circuit Amp. (rms) KA for 0.12 secduration at rated conductor temperature of 90 degree C, with an initial peak of 105 KA	45kA	45kA
b	Maximum Conductor temp. allowed for the short circuit duty (deg C.) as stated above	250°C	
9	Conductor		
a	Material	Stranded Aluminium as per Class 2 of IS : 8130	
b	Grade	H 2 (Electrolytic grade)	
c	Cross Section area (Sq.mm.)	630	300/150
d	Number of wires(No.) minimum	53	30/15
e	Form of Conductor	Stranded and compacted circular	Stranded compacted circular/sector Shaped
f	Direction of lay of stranded layers	Outermost layer shall be R.H lay & opposite	

Sr. No	Description	Parameters	
		in successive layers	
10	Conductor resistance (DC) at 20 °C per km-maximum	0.0469	0.1/0.206
11	Insulation		
a	Composition of insulation	Extruded XLPE as per IS-7098 Part (1)	
b	Nominal thickness of insulation(mm)	2.8	1.8/1.4
c	Minimum thickness of insulation	2.42	1.52/1.16
12	Inner Sheath		
a	Material	Extruded PVC type ST-2 as per IS-5831-84	
b	Calculated diameter over the laid up cores,(mm)	NA	52
c	Thickness of Sheath (minimum)mm	NA	0.6
d	Method of extrusion	NA	Pressure/Vacuum extrusion
13	Armour		
a	Type and material of armour	Al wire [H4 grade]	Gal. Steel wire
b	Direction of armouring	Left hand	
c	Calculated diameter of cable over inner sheath (under armour), mm	33.9	53.2
d	Nominal diameter of round armour wire (minimum)	2	2.5
e	Guaranteed Short circuit capacity of the armour for 0.12 sec at room temperature.	45kA	45kA
f	DC resistance at 20 °C (Ω/Km)	$	0.577
14	Outer Sheath	ST-2 & FR	ST-2 & FR
A	Material (PVC Type)	38.3	59.50
B	Calculated diameter under the sheath	1.72	2.36
C	Min. thickness of sheath(mm)	Min 29.0	Min 29.0
D	Guaranteed value of minimum oxygen index of outer sheath at 27 oC	Min 250	Min 250
E	Guaranteed value of minimum temperature index at 21 oxygen index	Black	Black
f	colour of sheath	$	$
15 a	Nominal Overall diameter of cable	+2/-2 mm	
b	Tolerance on overall diameter (mm)	shall conform to IS 10418 and technical specification	
16	Cable Drums	1000/500	1000/500
a	Max./ Standard length per drum for each size of cable (single length) with ±5% Tolerance (mtrs)		

Sr. No	Description	Parameters
b	Non-standard drum lengths	Maximum one(1) non-standard lengths of each cable size may be supplied in drums only over & above the standard lengths as specified above.(if required for completion ofproject)
17	Whether progressive sequential marking on outersheath provided at1 meter interval 18	Yes
18	Identification of cores	
a	colour of cores	As per IS 7098 Part(1)
b	Numbering	NA
19	Whether Cables offered are ISI marked	Yes
20	Whether Cables offered are suitable for laying as per IS 1255	Yes

$'- As per manufacturer design data

STANDARD TECHNICAL DATA SHEET - 1.1kV kV GRADE PVC POWER CABLES

SN	Description	Parameters					
1a	Cable Sizes	1 c x 150	3.5 c x 70	3.5 c x 35	4 c x 16	4c x 6	2 c x 6
1b	Manufacturer's type designation	AYWaY	AYFY	AYFY	AYFY	AYWY	AYWY
2	Applicable standard	IS: 1554/PT-I/1988 & its referred standards					
3	Rated Voltage(volts)	1100 V grade					
4	Type & Category	FR & C1	FR & C1	FR & C1	FR & C1	FR & C1	FR & C1
5	Suitable for earthed or unearthed System	for both					
6	Continuous current rating when laid in air in a ambient temp. of 50oC and for maximum conductortemp. of 70 deg C of PVC Cables [For information only]	202	105	70	41	24	28
7	Rating factors applicable to thecurrent ratings for various conditions of installation:	As per IS-3961-Pt-II-67					
8	Short circuit Capacity						
a)	Short Circuit Amp. (rms)KA for 1 sec duration	11.2	5.22	2.61	1.19	0.448	0.448
b)	Conductor temp. allowed for the short circuit duty (deg C.)	160^0C					
9	Conductor						
a)	Material	STRANDED ALUMINIUM					
b)	Grade	H 2 (Electrolytic grade)					

c)	Cross Section area (Sq.mm.)	150	M-70 N-35	M-35 N-16	16	6	6
d)	Number of wires(No.)	as per Table 2 of IS 8130					
e)	Form of Conductor	Non-compacted Stranded circular	shapedconductor	shaped conductor	shaped conductor	Non-compacted Stranded circular	Non-compacted Stranded circular
f)	Direction of lay of stranded layers	Outermost layer shall be R.H lay & opposite in successive Layer					
10	Conductor resistance (DC) at 20oC per km-maximum	0.206	0.443/0.868	0.868/1.91	1.91	4.61	4.61
11	Insulation						
a)	Composition of insulation	Extruded PVC type A as per IS-5831-84					
b)	Nominal thickness of insulation(mm)	2.1	1.4/1.2	1.2/1.0	1.0	1.0	1.0
c)	Minimum thickness of insulation	1.79	1.16/0.98	0.98/0.8	0.8	0.8	0.8
12	Inner Sheath						
a)	Material	Extruded PVC type ST-I as per IS-5831-84					
b)	Calculated diameter over the laid up cores,(mm)	N.A	27.6	20.4	15.7	11.6	9.6
c)	Thickness of Sheath (minimum) Mm	N.A	0.4	0.3	0.3	0.3	0.3
13	Armour	as per IS 3975/88					
a)	a) Type and material of armour	Al. Wire[H4 grade]	Gal.steel strip	Gal.steel strip	Gal.steel strip	Gal.steel wire	Gal.steel wire
b)	b) Direction of armouring	left hand					
c)	c) Calculated diameter of cable over inner sheath (under armour),mm	18	28.4	21	16.3	12.2	10.2
d)	d) Nominal diameter of roundarmour wire/strip	1.6 4	0.8 4	0.8 4	0.8	1.4	1.4
e)	e) Number of armour wires/strips	Armouring shall be as close as practicable					
f)	f) Short circuit capacity of the armour along for 1 sec- for infoonly	K x A√t (K Amp) (where A = total area of armour in mm^2& t = time in seconds), K=0.091 for Al & 0.05 forsteel					
g)	g) DC resistance at 20 °C (Ω/Km)	0.44	2.57	3.38 4	3.99	3.76	4.4
14	Outer Sheath						
a)	a) Material (PVC Type)	ST-1& FR	ST-1& FR	ST-1& FR	ST-1& FR	ST-1& FR	ST-1& FR
b)	b) Calculated diameter under the sheath	21.2	30.1	22.6	17.9	15	13
c)	c) Min. thickness of sheath(mm)	1.4	1.56	1.4	1.4	1.4	1.24
d)	d) Guaranteed value of minimum oxygen index of outer sheath at27oC	Min 29.0	Min 29.0	Min 29.0	Min 29.0	Min 29.0	Min 29.0

e)	e) Guaranteed value of minimum temperature index at 21 oxygenindex	Min 250	Min 250	Min 25 0	Min 250	Min 250	Min 250
f)	f) colour of sheath	Black	Black	Black	Black	Black	Black
15a)	a) Overall diameter of cable	$					
b)	b) Tolerance on overall diameter (mm)	+2/-2 mm					
16	Cable Drums	shall conform to IS 10418 and technical specification					
a)	a) Max./ Standard length per drumfor each size of cable (single length) with ±5% Tolerance (mtrs)	1000/5 0 0	1000/50 0	1000/ 5 00	1000/50 0	1000/5 0 0	1000/5 0 0
b)	b) Non standard drum lengths	Maximum one (1) non standard lengths of each cable size may be supplied in drums only over & above the standard lengths as specified above.(if required for completion of project)					
17	Whether progressive sequential marking on outer sheath provided	Yes					
18	Identification of cores						
a)	a) colour of cores	Red	R,Y,Bl & Bk	R,Y,B l& Bk	R,Y,Bl & Bk	R,Y,Bl & Bk	Red & Bk
b)	b) Numbering	N.A	N.A	N.A	N.A	N.A	N.A
19	Whether Cables offered are ISI Marked	YES					
20	Whether Cables offered are suitable for laying as per IS 1255	YES					

$'- As per manufacturer design data

STANDARD TECHNICAL DATA SHEET - 1.1kV kV GRADE PVC CONTROL CABLES

Sl. No	Description	Parameters							
1a	Cable Sizes	2 c x 2.5	3c cx 2.5	5c x 2.5	7 c x 2.5	10 c x 2.5	14 c x 2.5	19 c x 2.5	27 c x 2.5
1b	Manufacturer's type designation	YWY	YWY	YWY	YWY	YWY	YWY	YWY	YWY
2	Applicable standard	IS: 1554/PT-I/1988 & its referred standards							
3	Rated Voltage(volts)	1100 V grade							
4	Type & Category	FR & C1							

5	Suitable for earthed orunearthed system	for both							
6	Continuous current rating when laid in air in a ambient temp. of 50oCand for maximum conductor temp. of 70 oC of PVC Cables[For information only]	22	19	19	14	12	10.5	9.7	8
7	Rating factors applicable to the current ratings for various conditions of installation:	As per IS-3961-Pt-II-67							
8	Short circuit Capacity								
a)	Short Circuit Amp. (rms)KA for 1 sec duration	0.285	0.285	0.285	0.285	0.285	0.285	0.285	0.285
b)	Conductor temp. allowed for the short circuit duty (deg C.)	160^0C							
9	Conductor								
a)	Material	Plain annealed High Conductivity stranded Copper (as per IS8130/84)							
b)	Grade	Electrolytic							
c)	Cross Section area (Sq.mm.)	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
d)	Number of wires(No.)	as per Table 2 of IS 8130							
e)	Form of Conductor	Non-compacted Stranded circular shaped conductor							
f)	Direction of lay of stranded layers	Outermost layer shall be R.H lay							
10	Conductor resistance (DC) at 20 oC per km-maximum	7.41	7.41	7.41	7.41	7.41	7.41	7.41	7.41
11	Insulation								
a)	Composition of insulation	Extruded PVC type A as per IS-5831-84							
b)	Nominal thickness of insulation(mm)	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
c)	Minimum thickness of insulation	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71
12	Inner Sheath								
a)	Material	Extruded PVC type ST-I as per IS-5831-84							
b)	Calculated diameter overthe laid up cores,(mm)	7.2	7.8	9.7	10.8	14.4	15.9	18	22.1
c)	Thickness of Sheath (minimum)mm	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
13	Armour	as per IS 3975/99							

a)	Type and material of armour	Gal. Steel Wire							
b)	Direction of armouring	left hand							
c)	Calculated diameter of cable over inner sheath (under armour), mm	7.8	8.4	10.3	11.4	15	6.5	18.6	22.7
d)	Nominal diameter of round armour wire/strip	1.4	1.4	1.4	1.4	1.6	1.6	1.6	1.6
e)	Number of armour wires/strips	Armouring shall be as close as practicable							
f)	Short circuit capacity of the armour along for 1 sec-for info only	0.05 x A√t (K Amp)(where A = total area of armour in mm2 & t = time in seconds)							
g)	DC resistance at 20 oC(Ω/Km) & Resistivity	As per IS 1554 Part (1), wherever applicable and IS 3975-1999							
14	Outer Sheath								
a)	Material (PVC Type)	ST-1& FR							
b)	Calculated diameter under the sheath	10.6	11.2	13.1	14.2	18.2	19.7	21.8	25.9
c)	Min.thickness of sheath(mm)	1.24	1.24	1.24	1.24	1.4	1.4	1.4	1.56
d)	Guaranteed value of minimum oxygen index of outer sheath at 27oC	Min 29.0	Min 29.0	Min 29.0	Min 29.0	Min 29.0	Min 29.0	Min 29.0	Min 29.0
e)	Guaranteed value of minimum temperature index at 21 oxygen index	Min 250	Min 250	Min 250	Min 250	Min 250	Min 250	Min 250	Min 250
f)	colour of sheath	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey
15a)	Overall diameter of cable	$							
b)	Tolerance on overall diameter (mm)	+2/-2 mm							
16	Cable Drums	shall conform to IS 10418 and technical specification							
a)	Max./ Standard length per drum for each size ofcable (single length) with ±5% Tolerance (mtrs)	1000/500							
b)	Non standard drum lengths	**Maximum one(1) non standard lengths of each cable size may be supplied in drums only over & above the standard lengths as specified above.(if required for completion of project)**							
17	Whether progressive sequential marking on outer sheath provided								
18	Identification of cores	Yes							

a)	colour of cores	R & Bk	R, Y & Bl	Red R,Y,Bl	Grey	Grey	Grey	Grey	Grey
b)	Numbering	N.A	N.A	N.A	Numerals in black ink				
19	Whether Cables offeredare ISI marked	YES							
20	Whether Cables offered are suitable for laying asper IS 1255	YES							

$'- As per manufacturer design data

ANNEXURE-N

Technical Specification of Oil BDV Test Set (If specified in BPS)

Item	**Specification**
Functional Requirement	1. The instrument should be suitable for Automatic Measurement of Electrical Breakdown Strength of Transformer oil as per relevant standards. 2. The test results should have repeatability, consistency in laboratory condition.
Test Output	0-100 kV (Rate of rise: 0.5 to 5KV/Sec)
Accuracy	± 1 kV
Resolution	0.1 KV
Switch off Time	≤ 1ms
Display/Control	LCD/Keypads.

Printer	Inbuilt/External
Measurement Programmes	Fully Automatic Pre-programmed/User programmed Test Sequences including as per latest IEC & other national/international standards.
Test Lead/ Accessories	One complete set of electrodes, gauge etc. compatible with the instruments should be provided for successfully carrying out the test in EMPLYER S/S. Additionally, all the required accessories, tools, drawing, documents should be provided for the smooth functioning of kit. Further hard carrying case (which should be robust/rugged enough) for ensuring proper safety of the kit during transportation shall have to be provided.
Design/Engg.	The complete equipment along with complete accessories must be designed / engineered by Original Equipment Manufacturer.
Power Supply	It shall work on input supply variations, V: 230 ±10 %, f: 50 Hz ±5 % on standard sockets.
Operating Temperature	0 to +50 deg C
Relative humidity	Max. 90% non-condensing.
Protection/ Control	Against short circuit, over load, transient surges etc. Also the instrument should have facility of stopping automatically on power failure. Also the kit should have facility of HV chamber interlocking as well as zero start interlocking.
Environment	The test kit shall be compatible for EMI/EMC/Safety environment requirement as per IEC.
Guarantee	Warranty/Guarantee Period: Min 05 year from the date of successful & complete commissioning at Employer sub-station. All the materials, including accessories, cables, laptops etc. are to be covered under warranty/guaranty period. If the kit needs to be shifted to supplier's works for repairs within warranty/guaranty period, suppliers will have to bear the cost of spares, software, transportation of kit for repair at test lab / works.
Calibration Certificate	Unit shall be duly calibrated before supply and the date of calibration shall not be older than two months from the date of supply of Kit.
Training	Supplier shall have to ensure that the instrument is made user friendly. Apart from the detailed demonstration at site, the supplier shall also have to arrange necessary training to EMPLYER engineers.
Commissioning, handing over the Instrument	Successful bidder will have to commission the instrument to the satisfaction of EMPLOYER. The instrument failed during the demonstration shall be rejected and no repairs are allowed.
After sales service	Bidder will have to submit the documentary evidence of having established mechanism in India for prompt services.

ANNEXURE - O

Technical Specification of Portable Dissolved Gas Analysis of Oil (If specified in BPS)

Sl.No.	Particulars	Specification
01	Functional Requirement	The Portable DGA equipment to extract, detect, analyze and display the dissolved gases in insulating oil as specified in IEEE C 57-104- 2008 and IEC 60599-2007.
02	Detection of Gases	All the fault gases i.e. H2, CH4, C2H2, C2H4, C2H6, CO & CO2 concentrations shall be individually measured and displayed. The minimum detection limits of the instrument for the above gases shall strictly be met the requirement of IEC-60567-2011-Page No. 47-clause 9.2, table-5.
03	Power Supply	It shall be operated with AC single phase,50 Hz +/-5%, 230 V +/-10% supply. All power cable and necessary adaptors shall be provided by supplier.
04	Instrument control and Data handling, Internal Memory	a) Instrument shall be having in-built control for all the functions (data acquisitions and data storage), it shall have a facility for communication with computer for downloading the data from instrument via USB port. b) Laptop shall be provided for communication with the instrument. it shall be of latest specification along with licensed preloaded OS and software as well as software for interpreting DGA results accordance with IEEE C 57-104-1991 and IEC 60559-1999. Laptop carrying case shall also be provided. c) Internal Memory can capable of store atleast 15000 records

05	General Conditions	a) Performance Parameters like - Minimum Detection Limits, Working Range, Accuracy, repeatability etc. shall be finalized during detailed engineering. b) The portable DGA equipment supplier shall demonstrate during commissioning of the kit that the results shown by the kit are within the specified accuracy and repeatability range and EMPLOYER will provide only the insulating oil/ GAS-IN-OIL standard for testing. c) All required items/instruments /spares /consumable /connecting cables/communication cables/instruments/manuals/Certificates/training materials/original software/original licensed data/station operating software/education CD/DVDs that are essential to understand and operate the instrument shall be supplied at no extra cost.
06	Operating Temperature, Relative humidity & Dimensions	01. Temperature 0-50 Deg. C 02. 85% non-condensing 03. Portable
07	Warranty	The entire test set up shall be covered on warranty for a period of 5 years from the last date of complete commissioning and taking over the test set up. During this period, if the kit needs to be shifted to suppliers works for repairs, supplier will have to bear the cost of, spares, software, transportation etc. of kit for repair at test lab/works.
08	Service Support	The supplier shall furnish the requisite documents ensuring that the equipment manufacturer is having adequate service team and facility in India to take care of any issues during operation of the instrument.
09	Training	The supplier shall provide adequate training for a period of two working days pertaining to the operation and troubleshooting to site personnel.

ANNEXURE - P

On Line Dissolved Hydrogen and Moisture Monitor

1.0 Online Dissolved Hydrogen and Moisture Analyser along with all required accessories including inbuilt display shall be provided with each Transformer for measurement & analysis of dissolved gases and moisture in the oil. Interpretations shall be as per IEC 60599-1999

2.0 The equipment shall be capable of transferring data to sub-station automation system confirming to IEC 61850. Necessary interface arrangement shall be provided by the contractor for integration with automation system. The necessary type test report for such confirmation shall be submitted during detailed engineering

3.0 Equipment should work on station auxiliary supply. In case other supply is required for the equipment then suitable converter shall be included. All the necessary power and control cables, communication cables, cable accessories as required shall be provided by the supplier

4.0 Equipment shall be installed out door on Transformer in harsh ambient and noisy condition (Electromagnetic induction, Corona, and capacitive coupling). Equipment shall be mounted separately on ground. Suitable arrangement shall be provided to support and protect the inlet and outlet piping arrangement. The connecting oil lines must be of Stainless-Steel rigid pipes or flexible hoses. The equipment shall be suitable for proper operation in EHV substation (800kV) environment where switching takes place in the EHV/HV System. The suitable indications for power On, Alarm, Caution, normal operation etc. shall be provided on the front panel of the equipment. The equipment shall have IP55 Stainless Steel enclosure, suitable for 55 ^{0}C ambient temperature and EMI and EMC compatibility. The Equipment must carry a minimum of five (5) years manufacturer's Warranty

5.0 The equipment shall display H_2 and moisture concentration on its display unit and shall have facility to download all the stored the data from the unit for further analysis. The sampling rate shall be selectable as 2 or 4 or 6 or 12 hours etc. The equipment shall have inbuilt memory to store these results for complete one year even if sampling is done at the lowest interval. All the consumable (if any) upto warrantee period shall be included in the scope of supply

6.0 The monitor shall also be suitable to detect Water Content measured in ppm or % RS (Relative Saturation). The sensors shall be able to withstand pressure from vacuum to 10 psi.

7.0 Technical Parameters:

Sr. No.	**Parameters**	**Requirements**
a)	The measurement range / Output:	
	Hydrogen Dissolved in oil	0 to 2000 ppm, with 4 – 20 mA output
	Water Dissolved in oil	0 to 95% RS, with 4 – 20 mA output
b)	Alarms/Indication (High & Very High)	
	Hydrogen	Programmable NO/NC contacts,
	Water	Programmable NO/NC contacts,
c)	Environment	

	Operating Ambient Temperature	– 20 to + 55 deg C
	Operating Oil Temperature	– 20 to + 105 deg C
d)	Pressure Withstand, (Oil side)	Full Vacuum to 10 psi.
e)	Communications	USB&IEC 61850 compliant

Equipment shall be mounted separately to avoid effect of vibration. Suitable arrangement shall be provided support and protect the inlet and outlet piping arrangement.

8.0 Software for fault indication and fault diagnostics shall include following:

i) Fault indication
ii) IEEE, IEC or user configurable levels of dissolved gases
iii) Rate of change trending

9.0 The equipment shall be supplied with all necessary accessories required for carrying out DGA of oil sample complete in all respect as per the technical specification. The following shall be also form a part of supply:

Software

i) Operation Manual (2 set for every unit),
ii) Software Manual and
iii) Compact disc giving operation procedures of Maintenance Manual & Trouble shooting instructions.

10.0 The installation and commissioning at site shall be done under the supervision of OEM representative or OEM certified representative.

11.0 The equipment shall be covered on warranty for a period of 5 years from the last date of complete commissioning and taking over the test set up. During this period, if the kit needs to be shifted to suppliers works for repairs, supplier will have to bear the cost of, spares, software, transportation etc. of kit for repair at test lab/works. Further supplier shall make alternate arrangement for smooth operation of the transformer.

ANNEXURE - Q

On-line insulating oil drying system (Cartridge type)

In addition to provision of air cell in conservators for sealing of the oil system against the atmosphere, each Transformer shall be provided with an on-line insulating oil drying system of adequate rating with proven field performance. This system shall be separately ground mounted and shall be housed in metallic (stainless steel) enclosure. The bidder shall submit the mounting arrangement. This on-line insulating oil drying system shall be:

i. Designed for very slow removal of moisture that may enter the oil system or generated during cellulose decomposition. Oil flow to the equipment shall be controlled through pump of suitable capacity (at least 5 LPM).

ii. The equipment shall display the moisture content in oil (PPM) of the inlet and outlet oil from the drying system.

iii. In case, drying system is transported without oil, the same shall be suitable for withstanding vacuum to ensure that no air / contamination is trapped during commissioning.

iv. In case, drying system is transported with oil, the oil shall conform to EMPLOYER specification for unused oil. Before installation at site, oil sample shall be tested to avoid contamination of main tank oil.

v. Minimum capacity of moisture extraction shall be 10 Litres before replacement of cartridge. Calculation to prove the adequacy of sizing of the on line insulating oil-drying system along with make and model shall be submitted for approval of purchaser during detail engineering.

vi. The installation and commissioning at site shall be done under the supervision of OEM representative or OEM certified representative.

vii. The equipment shall be capable of transferring data to substation automation system confirming to IEC 61850 through FO port. Necessary interface arrangement shall be provided by the contractor for integration with automation system.

viii. The entire test set up shall be covered on warranty for a period of 5 years from the last date of complete commissioning and taking over the test set up. During this period, if the kit needs to be shifted to suppliers works for repairs, supplier will have to bear the cost of, spares, software, transportation etc. of kit for repair at test lab/works.

ix. The equipment shall be supplied with Operation Manual (2 set for every unit), Software (if any), and Compact disc giving operation procedures of Maintenance Manual & Trouble shooting instructions.

ANNEXURE - R

Nitrogen Injection Type Fire Prevention & Extinguishing System

1. Nitrogen Injection Type Fire Protection System (NIFPS) shall be designed to prevent explosion of transformer tank and the fire during internal faults/arc.

The system shall work on the principle of Drain & stir. On activation, it shall drain a pre- determined quantity of oil from the tank top through drain valve to reduce the tank pressure, isolate conservator tank oil and inject nitrogen gas at high pressure from the bottom side of the tank through inlet valves to create stirring action and reduce the temperature of oil below flash point to extinguish the fire. On operation, the quantity of oil removed from the tank shall be such that adequate amount of oil shall remain to cover active part (i.e., core coil assembly).

Electrical isolation of transformer shall be an essential pre-condition for activating the system.

2. Operational Controls

The system operation shall be fully automatic and activate from the required fire and other trip signals. In addition to automatic operation, remote operation from control room/ remote centre and local manual control in the fire extinguishing cubicle shall also be provided. System shall operate on following situations:

2.1 Prevention of transformer from explosion and fire

To prevent transformer from explosion and fire in case of an internal fault, signals given by operation of Electrical protection relays (Differential / Restricted earth fault) and tripping of circuit breaker of transformer and operation of either Buchholz relay or pressure relief valve (PRV) shall be used to activate the system. The exact logic for system activation shall be finalized during detailed engineering.

2.2 Prevention of transformer from fire in case of fire, sensed by fire detectors, the system shall be activated only after electrical isolation of the transformer, confirmed by breaker trip. If the fire detection is not associated with any other fault, the system activation shall be only manual. Manual operation switch shall be provided in the control room with a cover to avoid accidental operation of it.

3. Operation of System

On receiving activation signal, the following shall take place:

i) Open the quick opening drain valve to drain the top layer oil
ii) Shut off the conservator isolation valve to prevent flow of oil from the Conservator tank to the main tank
iii) Open the valve to inject Nitrogen into the transformer tank to create stirring of oil.

There shall be interlock to prevent activation of the system if the transformer is not electrically isolated.

There shall also be provision for isolating the system during maintenance and/or testing of the transformer.

4. Technical Particulars

The contractor shall be responsible for the design of the complete system and shall submit the drawings and design calculations for the number of fire detectors, pipe sizing of drain pipe and Nitrogen injection pipe, Nitrogen cylinder capacity, number of injection points, etc. and get approval from AEGCL.

Facility shall be provided to test the system when the transformer is in service, without actually draining the oil and injecting Nitrogen.

The Nitrogen regulator valve shall be designed in such a way that the Nitrogen shall not enter the transformer tank even in case of passing/ leakage of valve.

Owner shall provide two distinct station auxiliary DC feeders for control purposes. The system shall work on station DC supply with voltage variation defined in GTR. The control box of fire protection system shall have facility to receive these feeders for auto changeover of supply. It shall be the contractor’s responsibility to further distribute power to the required locations. In case auxiliary DC power supply requirement is different than station auxiliary DC supply, then all necessary DC-DC converters shall be provided by the Contractor.

Following minimum indications and alarms shall be provided in the local cubicle as well as in the control box: -

- Nitrogen cylinder pressure indication - manometer with sufficient number of adjustable NO contacts
- Nitrogen cylinder pressure low
- Fire in Transformer
- Oil drain started
- Conservator oil isolation valve closed
- Nitrogen injection started
- DC supply fail
- Oil drain valve closed
- Gas inlet valve closed

5. Details of Supply of System Equipment and Other Related Activities:

The scope of supply shall include the following items and any other items required for safe and trouble-free operation of the system.

i) Fire extinguishing cubicle with base frame and containing at least the following:
    - Nitrogen gas cylinder of sufficient capacity with pressure regulator and manometer with sufficient number of adjustable NO contacts.
    - Oil Drain Assembly including oil drainpipe extension of suitable size for connecting pipes to oil pit
    - Mechanical release device for oil drain and nitrogen release
    - Limit switches for monitoring of the systems
    - Panel lighting
    - Flanges on top of the panel for connecting oil drain and nitrogen injection pipes for transformer
    - Back up pressure switch to operate nitrogen gas valve
    - Pressure indicators for Nitrogen pressure of the cylinder and actual injection through Nitrogen regulator
    - Fire Extinguishing Cubicle shall have oil leakage detection arrangement

for detecting oil leakage from drain valve. In case of any oil leakages, alarm to be provided.

- shall have minimum IP55 degree of protection

ii) Control box to be installed in the control room of the station for monitoring system operation, automatic control and remote operation, with alarms, indications, switches, push buttons, audio signal, suitable for tripping and signalling.

iii) Required number of fire detectors to be located in strategic locations to be finalized during detailed engineering. Fire detectors shall have minimum IP-67 class degree of protection.

iv) All controls, alarms, panels, cables, cable trays (if required), junction boxes etc.

v) Flow sensitive conservator Isolation valve to isolate the conservator oil from the main tank is being provided by the transformer supplier. This valve shall be located in the piping between the conservator and the buchholz relay.

6. Under Ground Oil Storage Tank

Each transformer unit shall be provided with an underground oil storage tank. The oil storage tank shall have non-Corrosive, waterproof, epoxy coated (from Inside) mild steel (minimum thickness 5 mm) to store drained out oil on operation of NIFPS. The tank shall be painted from outside as per **table below:**

Painting	**Surface preparation**	**Primer coat**	**Intermediate undercoat**	**Finish coat**	**Total dry film thick-ness (DFT)**	**Colour shade**
Oil Storage Tank	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

Note: (*) indicates Sa 2 ½ as per Swedish Standard SIS 055900 of ISO 8501 Part-1.

The total capacity of storage tank shall be at least 10% of transformer tank oil to avoid overflowing of oil considering that drained oil volume shall be around 10% of transformer tank oil. Necessary arrangement shall be made on underground storage tank so as to take out the drained oil from the tank for further processing and use. All the pipe and physical connection from transformer to oil pit shall be in the scope of contractor.
This storage tank shall be placed in the pit made of brick walls with PCC (1:2:4) flooring with suitable cover plates to avoid ingress of rainwater. The design of tank and pit shall be finalised during detailed engineering.

7. The entire test set up shall be covered on warranty for a period of 5 years from the last date of complete commissioning and taking over the system.

8. Installation and pre-commissioning test After installation the system pre-commissioning tests shall be carried out jointly with the Owner’s representative before the system is put in service.

ANNEXURE-S

Oil sampling bottles

Oil sampling bottles (if specified in BPS) 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.

Oil sampling bottles shall be made of stainless steel having a capacity of 1litre. Oil Sampling bottles shall be capable of being sealed gas-tight and shall be fitted with cocks on both ends.

The design of bottle & seal shall be such that loss of hydrogen shall not exceed 5% per week.
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.

The scope of oil sampling bottles shall be included in the bid price as per the quantity indicated in the bid price schedule.

Oil Syringe

If specified in BPS, the glass syringe of capacity 50ml (approx.) and three way stop cock valve shall be supplied. The syringe shall be made from Heat resistant borosilicate Glass. The material and construction should be resistant to breakage from shock and sudden temperature changes, reinforced at luer lock tip Centre and barrel base.

The cylinder-Plunger fitting shall be leak proof and shall meet the requirement of IEC-60567. Plunger shall be grounded and fitted to barrel for smooth movement with no back flow. Barrel rim should be flat on both sides to prevent rolling and should be wide enough for convenient fingertip grip. The syringe shall be custom fit and uniquely numbered for matching. The syringe shall be clearly marked with graduations of 2.0 ml and 10.0 ml and shall be permanently fused for life time legibility.

ANNEXURE - T

Oil Storage Tank

1. Oil storage tank shall be of minimum capacity (as per BPS) along with complete accessories. The oil storage tank shall be designed and fabricated as per relevant Indian Standards e.g., IS 10987 (1992) or BS 2594. Transformer oil storage tanks **shall be towable on pneumatic tyres** and rested on manual screw jacks of adequate quantity & size. The tank shall be cylindrical in shape and mounted horizontally and made of mild steel plate of thickness as per standard. Diameter of the tank shall be 2.0 meter approximately. The tank shall be designed for storage of oil at a temperature of 100 deg C.

2. The maximum height of any part of the complete assembly of the storage tank shall not exceed 4.0 metres above road top.

3. The tank shall have adequate number of jacking pad so that it can be kept on jack while completely filled with oil. The tank shall be provided with suitable saddles so that tank can be rested on ground after removing the pneumatic tyres.

4. The tank shall also be fitted with manhole, outside & inside access ladder, silica gel breather assembly, inlet & outlet valve, oil sampling valve with suitable adopter, oil drainage valve, air vent etc. Pulling hook on both ends of the tank shall be provided so that the tank can be pulled from either end while completely filled with oil. The engine capacity in horsepower to pull one tank completely fitted with oil shall be indicated. Oil level indicator shall be provided with calibration in terms of litre so that at any time operator can have an idea of oil in the tank. Solenoid valve (Electro-mechanically operated) with Centrifugal pump shall be provided at bottom inlet so that pump shall be utilised both ways during oil fill up and draining. Suitable arrangement shall also be provided to prevent overflow and drain form the tank.

5. Each tank shall be thoroughly cleaned internally of all loose matter and then tested to a pressure of 0.7 bar, measured at the top of the tank as per standard. Tank shall also be tested at internal vacuum of 10mbar.

6. The following accessories shall also form part of supply along with each Oil storage tank.

7.1 Four numbers of 50NB suitable rubber hoses for Transformer oil application up to temperature of 100 deg. C, full vacuum and pressure up to 2.5 Kg/ cm2 with couplers and unions each not less than 10 metre long shall be provided.

7.2 Two numbers of 100NB suitable for full vacuum without collapsing and kinking vacuum hoses with couplers and unions each not less than 10 metre long shall also be provided.

7.3 One number of digital vacuum gauge with sensor capable of reading up to 0.001 torr, operating on 240V 50Hz AC supply shall be supplied. Couplers and unions for sensor should block oil flow in the sensor. Sensor shall be provided with at-least 8-meter cable so as to suitably place the Vacuum gauge at ground level.

7.4 The painting of oil storage tank and its control panel shall be as per technical specification.

7.5 The tank shall contain a self-mounted centrifugal oil pump with inlet and outlet valves, with couplers -suitable for flexible rubber hoses and necessary switchgear for its control. There shall be no rigid connection to the pump. The pump shall be electric motor driven, and shall have a discharge of not less than 6.0 kl/hr. with a discharge head of 8.0m. The pump motor and the control cabinet shall be enclosed in a cubicle with IP-55 enclosure.

ANNEXURE – U

Condition Controlled Maintenance Free Type Breather

1. The main Transformer tank conservator shall be fitted with a Maintenance-Free type silica gel Breather which shall be equipped with a microprocessor control unit and LED status indication.

2. Dehydrating breather's operating principle:

When the oil conservator breaths-in (e.g., at reduced load), the air flows through a filter made of high-grade steel wire mesh. The equipment fitted with filter & the dust cap, filters the dust, sand and other dirt particles from the air. The filtered air flows through the desiccant chamber filled with colorless, moisture adsorbing pellets and are dehydrated. The dehydrated air rises further via the pipe in the oil conservator. The desiccant is dehydrated by the built-in heating unit which is controlled by sensors, thus obviating the need for periodic desiccant replacement. The dehydrating breather is mounted on the pipe to the oil conservator at a height of 1200 mm approximately from transformer rail top level.

3. Technical **Features:**

3.1 Material & External Construction of the Breather shall be such that all external parts are suitable for outdoor use & resistive to transformer oil, ultraviolet rays, pollution & salt water and shall work without any trouble for ambient temperature between 0o C to +80o C.

3.2 Following LEDs for local display on control unit, and suitable contacts & analog signal shall be provided for wiring to remote location:

a) LED for Power of control unit - ON
b) LED for Filter heater- ON
c) LED for Anti-condensation heater (of control unit) - ON
d) LED & relay contact for "Device Error"
e) LED & relay contact for Regeneration active (De-humidification in process)
f) Analogue output signal (4-20mA) for the Temperature of air (in filter unit / pipe).

3.3 The Breather shall be equipped with test button which should allow to carry out a self-test and to check the functions like relay circuits, heating or the signal transmission in the control room, etc. at any time.

3.4 Control unit shall be equipped with a communication port for downloading the operational data logged by the unit. All necessary software required for downloading and analysing the logger data shall also be provided by the supplier. Supply of Laptop/PC for above software is not envisaged.

3.5 The moisture and temperature measurement system (sensor) installed should be modular making it easy to replace the same if at all the same is necessary during the service of breather.

3.6 The equipment shall operate at input supply of 230V AC, 50 Hz. Any converter if required shall be supplied with the equipment.

3.7 Degree of Protection shall be at least IP55 for which type Test report shall be submitted.

Necessary protective devices shall be provided in order to protect the equipment against over voltages & high-frequency interference.

3.8 The control unit shall be equipped with suitable heater to prevent moisture condensation.

3.9 The size of Condition controlled maintenance free dehydrating breather shall be decided based on the volume of transformer oil during detailed engineering.

4. The equipment shall be covered on warranty for a period of 5 years from the last date of complete commissioning and taking over. During this period, if the equipment needs to be shifted to suppliers works for repairs, supplier will have to bear the cost of, spares, software, transportation etc. of this equipment for repair at test lab/works. Further supplier shall make alternate arrangement for smooth operation of the transformer.

5. Condition Controlled Maintenance Free Type Breather of alternate proven technology shall also be acceptable.

Annexure-V

LIST OF CODES/STANDARDS/REGULATIONS/PUBLICATIONS

A list of Codes/Standards/Regulations/Publications which shall be used for design review, manufacturing, testing, erection, transportation etc. has been given below. In case of revision/amendment of these, revised/amended versions shall be followed.

IS 2026: Part 1 : 2011 (Reaffirmed Year : 2016)	-	Power transformers: Part 1 General
IS 2026: Part 2 : 2010 (Reaffirmed Year : 2020)	-	Power transformers Part 2 Temperature-rise
IS 2026: Part 3 : 2018	-	Power Transformers Part 3 Insulation Levels, Dielectric Tests and External Clearances in Air (Fourth Revision)
IS 2026: Part 4 : 1977 (Reaffirmed Year : 2016)	-	Power transformers: Part 4 Terminalmarking, tappings and connections
IS 2026 : Part 5 : 2011 (Reaffirmed Year : 2016)	-	Power Transformers Part 5 Ability toWithstand Short Circuit
IS 2026 : Part 6 : 2017	-	Power Transformers Part 6 Reactors
IS 2026 : PART 7 : 2009 (Reaffirmed Year : 2019)	-	Power Transformers Part 7 Loading Guidefor Oil-Immersed Power Transformers
IS 2026 : Part 8 : 2009 (Reaffirmed Year : 2019)	-	Power Transformers : Part 8 Applications guide
IS 2026 : Part 10 : 2009 (Reaffirmed Year : 2019)	-	Power Transformers : Part 10 Determinationof sound levels
IS 2026 : Part 10 : Sec 1 : 2018	-	Power Transformers part 10 Determinationof Sound Levels Section 1 Application guide
IS 2026 : Part 14 : 2018	-	Power Transformers Part 14 Liquid-Immersed Power Transformers Using High-Temperature Insulation Materials
IS 2026 : Part 18 : 2018	-	Power Transformers Part 18 Measurement ofFrequency Response
IEC 60076 All parts	-	Power Transformers

IS 3024 : 2015	-	Grain Oriented Electrical Steel Sheet and Strip (Third Revision)
IS 8468 : Part 1 : 2018 IEC 60214-1 : 2014	-	Tap-Changers Part 1 Performance Requirements and Test Methods (First Revision)
IEC / IEEE 60214- 2:2019		Tap-changers- Part 2: Application guidelines
IS 8478 : 1977 (Reaffirmed Year : 2016)	-	Application guide for on-load tap changers
IS 649 : 1997 (Reaffirmed Year : 2018)	-	Methods for testing steel sheets for magnetic circuits of power electrical apparatus
IS-10028 (Part 1, 2 & 3)	-	Code of practice for selection, installation & maintenance of transformer
IS 3639 : 1966 (Reaffirmed Year : 2016)	-	Fittings and Accessories for Power Transformers
IS 3637 : 1966 (Reaffirmed Year : 2016)	-	Gas Operated Relays
IS 335 : 2018	-	New Insulating Oils — Specification (Fifth Revision)
IEC 60296-2020	-	Fluids for electrotechnical applications – Mineral insulating oils for electrical equipment
IEC 60422 : 2013	-	Mineral insulating oils in electrical equipment - Supervision and maintenance guidance
IS 6792 : 2017	-	Insulating Liquids - Determination of the Breakdown Voltage at Power Frequency - Test Method (Second Revision)
IS/IEC 60137 : 2017	-	Bushings for alternating voltages above 1000 Volts
IS 12676 : 1989 (Reaffirmed Year : 2016)	-	Oil Impregnated Paper Insulated Condenser Bushings - Dimensions and Requirements
IS 4257 : Part 1 : 1981 (Reaffirmed Year : 2019)	-	Dimensions for Clamping Arrangements for Porcelain Transformer Bushings - Part I : For 12 kV to 36 kV Bushings
IS 4257 : Part 2 : 1986 (Reaffirmed Year : 2019)	-	Dimensions for clamping arrangements for porcelain transformer bushings: Part 2 For 72.5 kV and 123 kV bushings

IS 8603 : 2008 (Reaffirmed Year : 2019)	-	Dimensions for porcelain transformers bushings for use in heavily polluted atmospheres 12/17.5kV, 24kV and 36kV
IS 8603 : Part 4 : 2003 (Reaffirmed Year : 2019)	-	Dimensions for Porcelain Transformer Bushings for Use in Heavily Polluted Atmospheres - Part 4 : 52 kV Bushings
ANSI-C57.12.80	-	General requirements for Distribution, Power and Regulating Transformers
ANSI-C57.12.90	-	Test Code for Distribution, Power and Regulation Transformers
NEMA-TR-1	-	Transformers, Step Voltage Regulators and Reactors
IS 1747 : 1972 (Reaffirmed Year : 2016)	-	Nitrogen
IS-5: 2007	-	Colours for Ready Mixed Paints and Enamels
IS 3043 : 2018	-	Code of Practice for Earthing
IS 8263 : 2018	-	Radio Interference Test on High -Voltage Insulators (First Revision)
IS 8269 : 1976 (Reaffirmed Year : 2014)	-	Methods for switching impulse tests on high voltage insulators
IS 2071 : Part 1 : 2016	-	High-voltage Test Techniques Part 1 General Definitions and Test Requirements (Third Revision)
IS 16803 : 2018	-	High Voltage Test Techniques - Measurement of Partial Discharges by Electromagnetic and Acoustic Methods
IS/IEC 60270 : 2000 (Reaffirmed Year : 2016)	-	High — Voltage Test Techniques — Partial Discharge Measurements
IS 13235 : Part 1 : 2019	-	Short-Circuit Currents — Calculation of Effects Part 1 Definitions and Calculation Methods (First Revision)
IS 13235 : Part 2 : 2019	-	Short-Circuit Currents — Calculation of Effects Part 2 Examples of Calculation (First Revision)
IS 16227 : Part 1 : 2016 IEC 61869-2 : 2007	-	Instrument Transformers: Part 1 General requirements

IS 16227 : Part 2 : 2016 IEC 61869-2 : 2012	-	Instrument Transformers Part 2 Additional Requirements for Current Transformers
IS 16227 : Part 100 : 2018	-	Instrument Transformers Part 100 Guidance for Application of Current Transformers in Power System Protection
IS/IEC 60529 : 2001 (Reaffirmed Year : 2019)	-	Degrees of protection provided by enclosures (IP CODE)
IS/IEC-60947	-	Low voltage switchgear and control gear
IS 2062 : 2011 (Reaffirmed Year : 2016)	-	Hot Rolled Medium and High Tensile Structural Steel
IS 9595 : 1996 (Reaffirmed Year : 2019)	-	Metal arc welding of carbon and carbon manganese steels – Recommendations
IS 10801 : 1984 (Reaffirmed Year : 2016)	-	Recommended procedure for heat treatment of welded fabrications
IS 4253 : Part 1 & 2 : 2008 (Reaffirmed Year : 2019)	-	Cork Composition Sheets
IS 11149 : 1984 (Reaffirmed Year : 2019)	-	Rubber Gaskets
IS 12444 : 1988 (Reaffirmed Year : 2015)	-	Continuously cast and rolled electrolytic copper wire rods for electrical conductors
IS 513 : 2016	-	Cold Reduced Carbon Steel Sheet and Strip
IS 12615 : 2018	-	Line Operated Three Phase A.C. Motors (IE CODE) "Efficiency Classes and Performance Specification" (Third Revision)
IS/IEC 60034 : PART 5 : 2000 (Reaffirmed Year : 2018)	-	Rotating electrical machines : Part 5 Degrees of protection provided by the integral design of rotating electrical machines (IP CODE) – Classification
IS 5561 : 2018	-	Electric Power Connectors- Specification
IS 2932 : Part 1 : 2013 (Reaffirmed Year : 2018)	-	Enamel, Synthetic, Exterior : (a) Undercoating (b) Finishing - Specification : Part 1 for Domestic and Decorative Applications

IS 2074 : Part 1 : 2015	-	Ready Mixed Paint, Air Drying, Red Oxide - Zinc Chrome, Priming – Specification
IS 3400	-	Methods of Test for Vulcanized Rubber
IS 456 : 2000 (Reaffirmed Year : 2016)	-	Plain and Reinforced Concrete - Code of Practice (Including Amendment 1, 2, 3,& 4)
IS 13238 : 1991 (Reaffirmed Year : 2017)	-	Epoxy Based Zinc Phosphate Primer (two Pack)
IS 2848 : 1986 (Reaffirmed Year : 2016)	-	Industrial Platinum Resistance Thermometer Sensors
IS/IEC 61850	-	Communication Networks and Systems for Power Utility Automation
IS 16683 : Part 1, 2 & 3 : 2018	-	Selection and Dimensioning of High Voltage Insulators Intended for Use in Polluted Conditions
IEEE 1538-2000		Guide for determination of maximum winding temperature rise in liquid filled transformers
IEEE Standard C57.156-2016		Guide for tank rupture mitigation of oil immersed transformers
IEEE Standard C57.150-2012		Guide for Transformer Transportation
IEEE Standard C57.149-2012		Guide for the application and interpretation of Frequency Response Analysis of oil immersed transformers
IEEE Standard C57.104-2019		Guide for the Interpretation of Gases Generated in Mineral Oil-Immersed Transformers
IEC 60599-2015		Mineral oil-filled electrical equipment in service - Guidance on the interpretation of dissolved and free gases analysis
IEEE Std. C57.12.10 - 2017		Standard requirements for liquid immersed power transformers
IEEE Std. 57.104-2019		Guide for the Interpretation of Gases Generated in Mineral Oil-Immersed Transformers

IEC 60599		Mineral oil-filled electrical equipment in service – Guidance on the interpretation of dissolved and free gases analysis
IEEE Std. 62-1995		Guide for Diagnostic Field Testing of Electric Power Apparatus - Part 1: Oil Filled Power Transformers, Regulators, and Reactors
CIGRE Technical Brochure No. 529 -2013		Guide lines for conducting design reviews for Power Transformers
CIGRE Technical Brochure No. 673-2016		Guide on Transformer Transportation
CIGRE Technical Brochure No. 530-2013		Guide for conducting factory capability assessment for Power Transformers
CIGRE Technical Brochure No. 761 (WG A2.49)		Condition assessment of power transformers
CIGRE TB 209		Short Circuit Performance of Power Transformers
CIGRE TB 436		Experiences in service with new insulating liquids
Central Electricity Authority (Measures Relating to Safety and Electric Supply) Regulations		
Central Electricity Authority (Technical Standard for Construction of Electrical Plants and Electric Lines) Regulations		
Central Electricity Authority (Installation and Operation of Meters) Regulations		
CBIP Manual on Transformers (Publication No. 317)		
ISO 9001: Quality System – Model for Quality Assurance in Design/Development.		
ISO-14001 (Environmental Management System)		
OHSAS 18001 (Occupational Health and Safety Management System)		

Annexure-W

BASIC MANUFACTURING FACILITY & MANUFACTURING ENVIRONMENT

Customer/Purchaser always desires that transformer/reactor manufactured and delivered is of good quality and must perform trouble free service for its "Specified Design Life". The consistency in quality of material used & manufacturing process are main cause for variation in quality of transformer/reactor. It is also equally very important that transformer/reactor is manufactured in a clean dust free and humidity-controlled environment. Any compromise on this aspect will have adverse effect in expected design life of transformer/reactor, however good is the quality of material used. A broadlist of facilities the transformer/reactor manufacturers should have are given below:

<u>Basic manufacturing facility</u>

Following manufacturing facility should be available for use with transformer and reactor manufacturer:

1. EOT Crane for main manufacturing bay and other shops (With Load Cell).
2. Vapor Phase Drying Oven (adequately sized to accommodate offered transformer and have facility to record temperature, vacuum, moisture etc.)
3. Air Casters for material handling
4. Core cutting line (if applicable)
5. Vacuum auto claves
6. Air oven
7. Adjustable Horizontal and vertical winding machine
8. Winding Mandrels
9. Hydraulic Press
10. Brazing equipment
11. Mechanical platform
12. Tools and fixtures
13. Mechanical power press
14. Welding machines
15. Crimping tools
16. Faraday's cage
17. Motor Generator Set/ Static Power System Set
18. Testing transformer
19. Capacitor bank
20. Impulse voltage generator
21. Capacitance & Tan delta bridge

22. Power Analyzer
23. Current & Voltage transformer
24. Partial Discharge (PD) measuring kit (for all manufacturers) & PD Diagnostic Kit (for 400 kV & above voltage class Transformer/reactor manufacturer)
25. Temperature data logger
26. Noise measurement kit
27. Thermo vision camera
28. Loss measurement kit
29. Insulation tester
30. Winding resistance meter
31. Turn ratio meter
32. Transformer oil test lab
33. Dissolved Gas Analysis (DGA) test kit
34. Sweep Frequency Response Analyzer (SFRA) kit
35. Frequency Domain Spectroscopy (FDS) kit
36. NABL Accredited laboratory for testing
37. Oil Storage tanks
38. Oil filter plant with requisite level of vacuum and filter
39. Tensometer for Oil Surface tension
40. Particle Count Kit (for 400 kV & above Transformer/reactor)
41. Multimeters

<u>Manufacturing environment (Clean, dust free and humidity-controlled environment)</u>

A. Transformer must be manufactured in a bay having positive pressure w.r.t. external environment. Winding shall be manufactured ina clean, dust free and humidity-controlled environment. The dust particle shall be monitored regularly in the manufacturing areas. Further, there shall be positive atmospheric pressure, clean, dust free and humidity-controlled environment for following:

1. Insulation storage
2. Core storage
3. Glue stacking area
4. Core cutting line
5. Winding manufacturing bay

6. Core building area
7. Core coil assembly area
8. Testing lab
9. Packing & dispatch area

B. Following accessories to be kept in clean and covered location:

1. Piping
2. Radiator
3. Tank
4. Bushing (as per manufacturer’s guideline)
5. Marshalling box
6. Turret
7. Conservator
8. Insulating oil

Schedule-1

List of drawings to be submitted by successful bidder for approval of the

Project & Design Department

Sr. No.	Particulars of Drawing
1	General Arrangement (with provision of pockets for PT-100 sensors for remote /SCADA oil & Winding Temperature Indications) Overall dimensions to be restricted as per Clause 5.3
2	List of fittings as per G.A.
3	Rating and diagram plate (additional information such as Guaranteed /Measured losses; Guaranteed /Measured impedances at extreme and normal taps; Guaranteed /Measured Temperature rises for oil & winding; Core weight; Copper weight and Core & winding weight shall be invariably mentioned)
4	Over loading plate
5	Valve Schedule Plate
6	Foundation Plan
7	Transport Outline
8	H.V. Bushing
9	I.V. Bushing (as per requirement)
10	L.V. Bushing
11	Neutral Bushing
12	Terminal connector for
	I) HV
	ii) I.V. (as per requirement)
	iii) LV.
	iv) Tertiary (as per requirement)
13	Neutral Grounding bar Assembly
14	L.V. grounding Assembly

15	Conservator Tank.
16	Magnetic Circuit Earthing Details
17	Equalizing Pipe arrangement.
18	Oil filling Instruction plate
19	OLTC shaft connection diagram.
20	OLTC equalizing Pipe arrangement
21	General Arrangement of RTCC
22	OLTC Schematic with group simultaneous mode of control. Connectivity for tap raise -lower operations and Tap Position Indication through SCADA & TMCTS
23	OLTC legend
24	Schematic wiring for RTCC panel
25	RTCC legend
26	Radiators.
27	General Arrangement of Cooling Control Cabinet
28	Cable termination plan (Co-ordination) between OLTC & RTCC
29	Schematic for Facia Annunciator
	Schematic wiring for cooler control comprising
	i) Cooler control legend
	ii) Main and standby supply circuit alongwith heater and lighting circuit
	iii) Power circuit for Fans Gr. I, Gr. II & Standby
	iv) Control circuit for Fans Gr. I, Gr. II & Standby
	v) Power circuit for pumps Gr. I, Gr. II and Standby (as per requirement)
	vi) Control circuit for Pumps Gr. I, Gr. II, (as per requirement)
	vii) Lamp indication circuit
	viii) Annunciation Circuit
	ix) Oil & Winding Temperature Local indicating circuit / Alarm & Trip circuit for oil temp and winding temperature.
	x) Alarm & Trip Circuit (for MOG, PRV, Main Buchholz & OLTC Buchholz
	xi)) Wiring diagram of PT - 100 (for remote / SCADA WDG Temp. and Oil Temp. Indication)
	xii) Cable Termination Plan (Co-ordination) between a) FCC to RTCC

	b) FCC to OLTC
	c) FCC to C&R Panel
	xiii) Notes & Instructions
	xiv) REF Protection CT circuit.
30	Schematic wiring for TMCTS
31	General arrangement of optic fibre temperature measurement system. GA of Monitor Box and its schematic wiring diagram
32	General arrangement of on-line multi gas DGA for transformer oil and its schematic wiring diagram (as per requirement)
33	General arrangement of Condition controlled (Maintenance Free) Regenerating Silica Gel Breather for transformer oil (as per requirement)
34	Cable schedule
35	Roller Assembly
36	N2 Injection fire protection system drawing with Bill of material. (As per requirement)
37	HVWS fire protection system drawing with Bill of material. (As per requirement)
38	GTP for approval
39	Complete Bill of Materials.
40	QAP
41	Type Test Report conducted on identical transformer within last 5 years (if any)
42	I^2R calculations
43	Impedance calculations
44	Short circuit calculations
45	Cooling calculations
46	Core cutting schedule (Core shall be cut at Mill’s authorised processing unit only)

Schedule-2

Details of Loss Calculation
(To be filled in by the Bidder)

Sl. No	Particulars	Values
1.	Flux density at	
	(i) (145/36, 245/145, 245/145/36, 420/245) kV & 48.5 Hz, Tesla	
	(ii) (132/33, 220/132/33, 220/132, 132/33) kV & 50 Hz, Tesla.	
2.	Core Data	
	(i) Core weight in Kg.	
	(ii) Gross core area [mm²]	
	(iii) Stacking factor.	
	(iv) Net core iron area [mm²] [ii x iii]	
3.	Specific losses [W/Kg.]	
	(i) At maximum flux density corresponding to (145/36, 245/145, 245/145/36, 420/245) KV and 48.5 HZ.	
	(ii) At maximum flux density corresponding to (132/33, 220/132/33, 220/132, 132/33) KV and 50Hz.	
4.	Volt ampere/Kg	
	(i) At maximum flux density corresponding to (145/36, 245/145, 245/145/36, 420/245) KV and 48.5 HZ.	
	(ii) At maximum flux density corresponding to (132/33, 220/132/33, 220/132, 132/33) KV and 50Hz.	
5.	Calculated/guaranteed iron loss in KW at:	
	(i) Rated voltage and rated frequency	
	(ii) Rated voltage and rated frequency	
6.	Current density [A/Sq. mm] for	
	(i) HV	
	(ii) LV	
7.	Conductor size [in mm²]	
	(i) HV winding	
	a) Bare	
	b) Insulated	
	c) No of conductors in parallel	
	(ii) LV winding	
	a) Bare	
	b) Insulated	
	c) No of conductors in parallel	
8.	Copper weight	
	(i) H.V. windings	

Sl. No	Particulars	Values
	(ii) LV windings	
	(iii) For Tap connections,	
	(iv) Total copper weight [i]+[ii]+[iii]	
9.	L.V. winding resistance in ohms at 75°C/Phase.	
10.	H.V. winding resistance in ohms at 75°C/Phase.	
	(i) At normal tap position	
	(ii) At maximum tap position	
	(iii) At minimum tap position	
11.	Stray losses and eddy current losses [in KW] at 75°C	
	(i) At normal tap position	
	(ii) At maximum tap position	
	(iii) At minimum tap position	
12.	Resistively of copper to be used for winding	
13.	I^2R loss at 75°C	
	(i) At normal tap position	
	(ii) At maximum tap position	
	(iii) At minimum tap position	
14.	Calculated guaranteed copper losses [in KW] at 75°C	
	(i) At normal tap position	
	(ii) At maximum tap position	
	(iii) At minimum tap position	
15.	Guaranteed Auxiliary loss	
16.	Computed/guaranteed total loss in KW at rated	
	(i) At normal tap position	
	(ii) At maximum tap position	
	(iii) At minimum tap position	

NB: - 1. Approximate values in weight and losses etc. are not allowed.

2. Tolerance of + 5% in weights may be quoted without any approximation

Place:

Date:

Bidder's name:
Signature, designation, seal

Schedule-3

Maximum Flux Density and Core Weight Calculation

(To be filled in by the Bidder)

Step No	Width of steps [mm]	Stack Thickness [mm]	Gross Iron Area [mm^2]
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

Bmax = **E/ (4.44 x f x Ai x N)**

Where, E = L.V. winding phase voltage / phase
f = Rated frequency = 50 HZ.
Bmax. = Maximum flux density in Tesla.
Ai = Net iron area in sq. m = Gross iron area x stacking factor in sq. m
N = Number of L.V. winding, turns/phase
Stacking Factor = 0.97 maximum

Core weight calculation: -
Core dia [in mm] =
Window height [in mm] = Limb centre [in mm] =
Weight of core = [3 x window height + 4 x limb centre + 2 x max. width] x Net iron area x Density of core

NB: -
1 Specific loss vs. flux density graph for the type of core lamination to be used has to be furnished.
2. VA/Kg. Vs flux density graph for the core lamination to be used has to be furnished.
3. Any other factor assumed for above calculation to be explained with reasons.

N.B: - The bidder may use its own method of calculation towards determination of maximum flux Density and weight of the core. But the same shall be supported with proper explanation and Justification.

Place:
Date:

Signature of Bidder
With seal of Company.

Schedule-4

Manufacturer Quality Plan (MQP)

Sl No.	Component	Characteristics	Type of Inspection	Quantum of Inspection	Ref Doc & Acceptable Norm	Form of Record	Inspection Agency	Remarks
1.0	**MATERIAL**							
1.1	**Copper Conductor**							
1.1.1		Samplecheck on winding conductor for electrical conductivity	Testing	Sampling/lot	TM Spec	Insp.record	Vendor/TM QC	CHP at Vendor end
1.1.2		Dimensions Width & Thickness (Bare) & Visual for scratches, dentarks	Measurement	-Do-	TM Spec	-Do-	-Do-	CHP at Vendor end
1.1.3		Sample check on insulating paper for pH value, electric strength	Testing	-Do-	TM Spec	-Do-	-Do-	TC Review
1.1.4		check for bonding of the insulating paper with conductor	Visual	-Do-	TM Spec	-Do-	-Do-	CHP at Vendor end
1.1.5		Check for the reaction of hot oil andinsulating Paper	Testing	-Do-	TM Spec	-Do-	-Do-	TC Review
1.1.6		Check & ensure that physical condition of all materials taken for winding is satisfactory and dust free.	Visual	-Do-	TM Spec	-Do-	-Do-	CHP at Vendor end
1.2	**Core Material**							
1.2.1		Sample testing of core materials for checking specific core loss properties, magnetization characteristics & Thickness	Testing	Sampling/lot	TM Spec	Insp.record	Vendor/TM QC	CHP at Vendor end
1.2.2		Amount of burr	Measurement	-Do-	-Do-	-Do-	-Do-	CHP at Vendor end
1.3	**Insulating Material**							
1.3.1		Physical Properties	Testing	Sampling/lot	TM Spec	Insp.record	Vendor/TM QC	TC Review
1.3.2		Dielectric	Testing	Sampling/l	TM Spec	Insp.record	Vendor/TM	TC

Sl No.	Component	Characteristics	Type of Inspection	Quantum of Inspection	Ref Doc & Acceptable Norm	Form of Record	Inspection Agency	Remarks
		Strength		ot		ord	QC	Review
1.3.3		Reaction of hot oil on insulating Materials	Testing	Sampling/lot	TM Spec	Insp.record	Vendor/TM QC	TC Review
1.4	**OIL**							
1.4.1		Appearance	Visual	Sampling	IS 335/TM Spec	Insp Record	Vendor/TM QC	CHP at Vendor end
1.4.2		Density	Testing	-Do-	-Do-	-Do-	-Do-	
1.4.3		Viscosity	Testing	-Do-	-Do-	-Do-	-Do-	
1.4.4		Interfacial Tension	Testing	-Do-	-Do-	-Do-	-Do-	
1.4.5		Neutralisation Value	Testing	-Do-	-Do-	-Do-	-Do-	
1.4.6		Dielectric Strength	Testing	-Do-	-Do-	-Do-	-Do-	
1.4.7		Tan Delta	Testing	-Do-	-Do-	-Do-	-Do-	
1.4.8		Specific Resistance	Testing	-Do-	-Do-	-Do-	-Do-	
1.4.9		Water content	Testing	-Do-	-Do-	-Do-	-Do-	
1.4.10		Flash point	Testing	-Do-	-Do-	-Do-	-Do-	
1.4.11		Pour point	Testing	-Do-	-Do-	-Do-	-Do-	
1.4.12		Corrosive sulphur	Testing	-Do-	-Do-	-Do-	-Do-	
1.4.13		Oxidation stability (a)Neutralization after oxidation (b)Total sludge after Oxidation	Testing	-Do-	-Do-	-Do-	-Do-	
1.4.14		Ageing characteristics after accelerated Ageing	Testing	-Do-	-Do-	-Do-	-Do-	
1.4.15		Presence of oxidation Inhibitor	Testing	-Do-	-Do-	-Do-	-Do-	
1.4.16		SK value	Testing	-Do-	-Do-	-Do-	-Do-	
2.0	**FITTINGS AND ACCESSORIES**							
2.1	Tank & Conservator Raw material							
2.1.1		Type of material	TC Verif	Sampling	TM Spec	Insp Record	Vendor/TM QC	
2.1.2		Thickness	Testing	-Do-	-Do-	-Do-	-Do-	CHP at Vendor end
2.2	**Tank & conservator Assembly**							
2.2.1		Inspection of major welds.	Visual	Each Unit	TM Spec	Insp Record	Vendor/TM QC	CHP at Vendor end
2.2.2		NDT for load bearing(Jacking pad, lifting bollard)	Testing	Each Unit	TM Spec	Insp Record	Vendor/TM QC	CHP at Vendor end

Sl No.	Component	Characteristics	Type of Inspection	Quantum of Inspection	Ref Doc & Acceptable Norm	Form of Recod	Inspection Agency	Remarks
		Welds(DP test)						
2.2.3		dimensions between wheels, demonstrate turning of wheels through 90 deg. & further dimensional check	Testing	Each Unit	TM Spec	Insp Record	Vendor/TM QC	CHP at Vendor end
2.2.4		Leakage Test of conservator	Testing	Each Unit	TM Spec	Insp Record	Vendor/TM QC	CHP at Vendor end
2.2.5		Measurement of film thickness of	Testing	Each Unit	TM Spec	Insp Record	Vendor/TM QC	CHP at TM for total DFT measurement during final inspection
		(i) Zinc chromate Paint	Meas	-Do-	-Do-	-Do-	-Do-	
		(ii) Finished coat	Meas	-Do-	-Do-	-Do-	-Do-	
2.2.6		-Pressure &Vacuum test	One unit/Rating	-Do-	-Do-	-Do-	-Do-	CHP at Vendor end
2.3	**Radiator**							
2.3.1		Visual & Dimension	Measurement	Each Unit	TM Spec	Insp Record	Vendor/TM QC	
2.3.2		Pressure test & leakage test	Testing	-Do-	-Do-	-Do-	-Do-	
2.3.3		Paint thickness	Measurement	-Do-	-Do-	-Do-	-Do-	
2.4	**Marshalling box & RTCC**							
2.4.1		Dimension (WxDxH of panel)	Measurement	Each Unit	TM Spec	Insp Record	Vendor/TM QC	
2.4.2		Meas. of 2 kV dielectric test	Testing	-Do-	-Do-	-Do-	-Do-	CHP
2.4.3		Component make & Rating	Visual	-Do-	-Do-	-Do-	-Do-	
2.4.4		Completeness, label Fixing & Finishing	Visual	-Do-	-Do-	-Do-	-Do-	
2.4.5		Functional test	Visual	-Do-	-Do-	-Do-	-Do-	
2.4.6		IP:55 test for M. Box	Testing	1 unit/rating	IS 2147	-Do-	-Do-	CHP
2.5	**Temperature indicators (OTI, WTI)**							
2.5.1		Type	Visual	Each Unit	TM Spec	Insp Record	Vendor/TM's QC	
2.5.2		Continuity check	Manual	-Do-	-Do-	-Do-	-Do-	
2.5.3		Switch setting & Calibration	-Do-	-Do-	-Do-	-Do-	-Do-	

2.6	**Buchholz Relay**							
2.6.1		Type/Model	Visual	-Do-	-Do-	-Do-	-Do-	
2.6.2		Continuity of Contacts	Manual Check	-Do-	-Do-	-Do-	-Do-	
2.6.3		Operation of Contacts	Manual Check	-Do-	-Do-	-Do-	-Do-	
2.7	**Bushings**							
2.7.1		Test for leakage on	TC Verify	Each Unit	IS 2099/TM	Insp	Vendor/TM	

Sl No.	Component	Characteristics	Type of Inspection	Quantum of Inspection	Ref Doc & Acceptable Norm	Form of Record	Inspection Agency	Remarks
		internal fillings (Tightness test)			Spec	Record	's QC	
2.7.2		Dry power frequency test on terminal & tapping	TC Verif	Each Unit	IS 2099/TM Spec	Insp Record	Vendor/TM 's QC	
2.7.3		Measurement of dielectric dissipation factor & Capacitance	TC Verif	Each Unit	IS 2099/TM Spec	Insp Record	Vendor/TM 's QC	
2.7.4		Partial discharge test followed by dielectric dissipation factor & capacitance measurement for condenser bushings & creepage distance measurement.	Testing	Each Unit	IS 2099/TM Spec	Insp Record	Vendor/TM 's QC	CHP at Vendor end
2.8	**Current Transformers**							
2.8.1		Type & finish	Visual	Each lot	TM's Spec	Insp Record	Vendor/TM 's QC	
2.8.2		Dimensions (OD,ID & H)	Measur	Each Unit	-Do-	-Do-	-Do-	
2.8.3		Verification of Terminal Marking & Polarity	Testing	Each Unit	-Do-	-Do-	-Do-	
2.8.4		P.F.dry withstand Test	-Do-	-Do-	-Do-	-Do-	-Do-	
2.8.5		Overvoltage interturn test	-Do-	-Do-	-Do-	-Do-	-Do-	
2.8.6		Determination of Errors	-Do-	-Do-	-Do-	-Do-	-Do-	
2.9	**Pressure relief Valve/Sudden pressure relay**							
2.9.1		Type/ Model	Visual	Each Unit	TMs Spec	Insp Record	Vendor/TM 's QC	
2.9.2		Manual operation of Switch contacts	Manual Check	-Do-	-Do-	-Do-	-Do-	
2.9.3		Operating pressure	Testing	-Do-	-Do-	-Do-	-Do-	
2.10	**MOLG**							
2.10.1		Type/ Model	Visual	Each Unit	TMs Spec	Insp Record	Vendor/TM 's QC	
2.10.2		Dial Calibration	TC Verif	-Do-	-Do-	-Do-	-Do-	
2.10.3		Switch Continuity	Manual Check	-Do-	-Do-	-Do-	-Do-	

Sl No.	Component	Characteristics	Type of Inspection	Quantum of Inspection	Ref Doc & Acceptable Norm	Form of Record	Inspection Agency	Remarks
2.11	**Valves**							
2.11.1		Type & Size	Visual	Each Unit	Customer Spec	Insp Record	Vendor/TM 's QC	
2.11.2		Open & shut marking	-Do-	-Do-	-Do-	-Do-	-Do-	
2.11.3		Leakage test	TC Varif					
2.12	**Silica gel breather**							
2.12.1		Type/ Model	Visual	Each Unit	TMs Spec	Insp Record	Vendor/TM 's QC	
2.13	**Online H_2 & Moisture monitoring**							
2.13.1		Type / Model	Visual	Each Unit	TMs Spec	Insp	Vendor/TM	
						Record	's QC	
2.14	**Tap changer**							
2.14.1		Type & Rating	Visual	Each Unit	TMs Spec	Insp Record	Vendor/TM 's QC	
2.14.2		Physical condition	Visual	Each Unit	TMs Spec	Insp Record	Vendor/TM 's QC	
2.14.3		Mechanical Operation Check	Testing	Each Unit	TMs Spec	Insp Record	Vendor/TM 's QC	
2.14.4		Insulation Resistance Test	Testing	Each Unit	TMs Spec	Insp Record	Vendor/TM 's QC	
2.15	**Cooling fan**							
2.15.1		HV test	Testing	Each Unit	IS 2312	Insp Record	Vendor/TM 's QC	
2.15.2		Insulation Resistance Test	-Do-	-Do-	-Do-	-Do-	-Do-	
2.15.3		Performance Test	-Do-	-Do-	-Do-	-Do-	-Do-	
2.15.4		DFT of Galvanization on Fan guard	-Do-	-Do-	TM's Spec	-Do-	-Do-	
3.0	**MANUFACTURING**							
3.1	**Assembled Core**							
3.1.1		Visual & dimensional check during assembly stage	Visual/ Meas	Each Assembly	TM's Spec	Insp Record	Vendor/TM 's QC	CHP at TM's Works
3.1.2		Check on completed core for measurement of iron loss	Meas/Testing	Each Assembly	Customer Spec	Insp Record	Vendor/TM 's QC	CHP at TM's Works
3.1.3		2KV H.V.test (Core insulation test) between Core & clamps for one minute And Insulation resistance test of core & clamps (clamps)	Testing	Each Assembly	Customer Spec	Insp Record	Vendor/TM 's QC	CHP at TM's Works

Sl No.	Component	Characteristics	Type of Inspection	Quantum of Inspection	Ref Doc & Acceptable Norm	Form of Record	Inspection Agency	Remarks
3.1.4		Visual & dimensional checks for straightness & roundness of core, thickness of limbs and suitability of clamps	Visual	-Do-	-Do-	-Do-	-Do-	CHP at TM's Works
3.2	**Wound Coils**							
3.2.1		Visual check for brazed joints wherever Applicable	Visual	Sampling/Lot	TM's Spec	Insp Record	Vendor/TM's QC	CHP at TM's Works
3.2.2		Visual check of insulation on the conductors & between the windings	Visual	Sampling/Lot	TM's Spec	Insp Record	Vendor/TM's QC	CHP at TM's Works
3.2.3		Check for the absence of short circuit between parallel strands of PICC	Testing	-Do-	-Do-	-Do-	-Do-	CHP at TM's Works
3.3	**Coil & Core assembled**							
3.3.1		Active part before drying						
		(i) Visual check	Visual	Each Unit	TM's Spec	Insp Record	Vendor/TM's QC	CHP at TM's Works
		(ii) Check insulation distance between high voltage connections, between high voltage connection cables & earth and other live parts	Meas	-Do-	-Do-	-Do-	-Do-	CHP at TM's Works
		(iii) Check insulating distance between low voltage connections and earth and other parts	Meas	-Do-	-Do-	-Do-	-Do-	CHP at TM's Works
		(iv) 2KV core insulation test	Testing	-Do-	-Do-	-Do-	-Do-	CHP at TM's Works
3.3.2	Active part after drying							
		(i) Measurement & recording of temperature & drying time during vacuum treatment	VPD Data	Each Unit	TM's Spec	Insp Record	TM's testing/TM's QC	**In process check card review by Custo**

								mer
		(ii) Check for completeness of drying	VPD Data	Each Unit	TM's Spec	Insp Record	TM's testing/TM's QC	**In process check card review by Customer**
3.4	**Assembled Transformer**							
3.4.1		Check Completed transformer against approved outline drawing, provision for all fittings, finish levels etc.	Visual	One Transformer of each rating	Approved GA drawing	Insp Record	TM's testing/TM's QC	**CHP at TM's Works**
3.4.2		Jacking test	Visual	-Do-	-Do-	-Do-	-Do-	**CHP at TM's Works**
3.5	**Final Testing**							
3.5.1	**Routine Tests**							

Sl No.	Component	Characteristics	Type of Inspection	Quantum of Inspection	Ref Doc & Acceptable Norm	Form of Record	Inspection Agency	Remarks
3.5.1.1		Winding resistance Test	Testing	Each Unit	IS 2026/IEC 60076	Insp Record	Customer/ TM	**CHP at TM's Works**
3.5.1.2		Turn ratio, Polarity						
3.5.1.3		Vector group test and Phase vector relationship test						
3.5.1.4		Load loss & impedance voltage						
3.5.1.5		No-load loss and current Measurement						
3.5.1.6		Measurement of magnetization current at low voltage.						
3.5.1.7		Insulation Resistance Measurement						**CHP at TM's Works**
3.5.1.8		Separate source voltage withstand test for all windings (1 Minute)						

3.5.1.9		Induced over-voltage withstand test for 60 Sec. @ 100 Hz						
3.5.1.10		Full wave lightning impulse on three Phases						
3.5.1.11		Measurement of partial discharge at the time of induced over voltage test						
3.5.1.12		Frequency response analysis (FRA)						
3.5.1.13		Measurement of zero sequence impedance of three phase transformers.						
3.5.1.14		Measurement of acoustic noise level						
3.5.1.15		Measurement of the harmonics of the no-load current						
3.5.1.16		Measurement of capacitance and ten δ to determine capacitance between winding and earth. Value of tanδ should not be more than 0.5% at 20°C						
3.5.1.17		Oil leakage test on						
Sl No.	Component	Characteristics	Type of Inspection	Quantum of Inspection	Ref Doc & Acceptable Norm	Form of Record	Inspection Agency	Remarks
		transformer tank as per CBIP						
3.5.1.18		Test on OLTC						
3.5.1.19		Magnetic balance Test						
3.5.2	**Type Test**							
3.5.2.1		Temperature-rise test with 2 x 50% radiator banks including DGA test after & before temp rise test	Testing	One Unit on each rating	IS 2026/IEC 60076	Insp Record	Customer/ TM	**CHP at TM's Works**
3.5.2.2		Measurement of the power taken by the fans						**CHP at TM's Works**
3.5.2.3		Pressure & Vacuum test on transformer tank as per CBIP						
3.6	**Pre-shipment check**							
3.6.1		Detach accessories for despatch	Visual	Each unit	TM's spec	Insp Record	TM	

3.6.2		Blanking of Openings	-Do-	-Do-	-Do-	-Do-	-Do-	
3.6.3		Adjustment of oil Level/ Draining of Oil	-Do-	-Do-	-Do-	-Do-	-Do-	
3.6.4		Finishing, cleaning & Painting touch up	-Do-	-Do-	-Do-	-Do-	-Do-	
3.6.5		Dew point measurement before despatch	Testing	-Do-	-Do-	-Do-	-Do-	**Reqd for only Transfo r mer despat ch without oil**
3.6.6		Gas tightness test to confirm tightness	Testing	-Do-	-Do-	-Do-	-Do-	
3.6.7		Check for proper packing of detached accessories for dispatch & Check for proper provision of bracing to arrest the movement of core &winding assembly inside the Tank	Testing	-Do-	-Do-	-Do-	-Do-	

Note:

1. TM – Transformer Manufacturer

2. CHP – Customer Hold Point

3. Further details of MQP shall be as per ‘Guidelines for Model Quality Assurance Plan (MQAP) for major equipment of Power sector’ of CEA.

CHAPTER 18: TECHNICAL SPECIFICATION FOR 220V DC BATTERY AND CHARGER

A. VALVE REGULATED LEAD ACID BATTERY

18.1. **SCOPE :**

(i) The scope covers the design, manufacture, assembly, testing at the manufacturer's works, delivery at site, installation, testing and commissioning of 220 V D.C. Maintenance free Valve regulated Lead Acid Battery and associated battery charger with provisions of both float and boost charging of battery along with necessary accessories, fittings, etc for 400kV, 220kV and 132 kV sub-stations.

Each battery shall have sufficient capacity considering continuous emergency and intermittent loads for the periods specified below and for all bays with the charger out of service:

a) Continuous DC load for protection, control, indications, alarms and interlock for 10 hours.

b) Emergency lighting loads for 10 hours.

c) Intermittent DC load for closing and tripping operation of Circuit Breakers, Isolators and Earth Switches. This load shall be determined considering simultaneous tripping of breakers on bus-bar protection. Duration of intermittent load shall be considered as one minute when **the battery has reached the end cell voltage**. **Battery shall be of 2X100%capacity** and shall have 20% spare capacity **with matching 2x 100% battery charger.** Supplier shall furnish characteristic curve for satisfactory operation and maintenance of battery under service condition.

Bidder shall select number of cells, float & boost voltage to achieve following system requirement:

System Voltage During Float	Maximum Voltage During Float operation	Minimum Voltage available when no charger working and battery fully discharged upto 1.85V per cell.	Minimum no of cells.
220V	242V	198V	109V
48V	52.8V	43.2V	24V

Bidder shall furnish calculation in support of selection of capacity as well as number of Cells, Float & Boost charger current / Voltages.

(ii) The scope also covers the design, manufacture, assembly, testing at the manufacturer's works of 48 V D.C. Maintenance free Valve regulated Lead Acid Battery, having minimum capacity of 300 AH and associated battery charger with provisions of both float and boost charging of battery along with necessary accessories, fittings etc.

Each battery shall have sufficient capacity for continuous DC supply to PLCC Terminals, Protection Coupler Units, Fiber Optic Terminals, EPAXes, Remote Terminal Unit (RTU) etc. as and when required as well as float charging current of the battery.

The battery shall consist of 24 number of cells, float & boost voltage to achieve a system voltage 48V. Battery shall be of **2x100% capacity** andshall have 20% spare capacity with **matching 2x 100% battery charger.** Supplier shall furnish characteristic curve for satisfactory operation and maintenance of battery under service condition.

18.2. RATING OF BATTERY AND FUNCTION OF CHARGER:

D.C. Power Supply shall comprise a set of Battery (220V) of desired capacity, a Float charger and a Float cum Boost Battery Charger (minimum 60A) in parallel operation. In this mode the charger shall be required not only to continuously feed a variable load but also deliver trickle/boost charging current for the battery. Charger shall have 20% spare capacity. Battery will be capable of feeding the DC load requirement of the Sub-station in case of failure of the charger. Ampere-hour capacity of the battery shall be designed considering the current load and expected future load due to extension of the Sub-Station (if not specified, then minimum 3 nos of future bays are to be considered for each voltage class). A detailed design calculation for both battery & charger are to be submitted for approval.

18.3. TRICKLE / BOOST CHARGE VOLTAGE:

The trickle and Boost charge voltage per cell shall be as follows:

a) 220V Battery Bank

i) TRICKLE CHARGE: Per Cell Voltage 2.2 V to 2.25±0.02 V

ii) Boost charge voltage should vary between 2.23 to 2.3V/cell.

18.4. VOLTAGE / CURRENT REGULATION OF CHARGER:

Output voltage for float charging from battery charger shall be auto controlled by adjusting the firing angle of thyristor for float charger to keep the voltage variation within ± 1% from no load to full load and AC supply voltage variation of ±10% and frequency variation of ± 3% of 50 Hz. Manual control of output voltage shall also be possible through Auto/Manual selector switch.

The Boost / Quick charger shall be similar type as Float / Trickle charging equipment, but shall be provided with control arrangement for ‘auto/manual’ current regulation featureswith current adjustment setting upto 150%, necessary for quick charging. An automatic VOLTAGE controller for boost charging shall control the output VOLTAGE WITH CURRENT LIMIT AS LIMITED FOR RESPECTIVE BATTERY CAPACITY by adjusting the firing angle of the thyristor.

18.5. CLIMATIC CONDITIONS:

The equipment to be supplied against the specification shall be suitable for satisfactory continuous operation under the climatic condition mentioned in chapter 2 of this bidding document.

18.6. DESCRIPTION OF BATTERY:

18.6.1 Type:

The DC batteries shall be VRLA (Valve regulated Lead Acid) type & shall be Normal Discharge type and shall conform to IS 15549:2004/ IEC 60896-21 & 22:2004/ BS 6290-PART IV/ IEEE-1188 standard. These batteries are to be factory-filled, charged & shall be suitable for a long life under continuous float operations & occasional discharges. The 220V DC system is unearthed system. The offered battery shall be compact and shall require no maintenance. All safety equipment required for installation shall be provided by the manufacturer.

18.6.2 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.

18.6.3 Plates:

Positive plates shall be made pasted type using high purity corrosion resistant alloy for deep discharge, durability, maintenance free, long life both in cyclic as well as in float applications. The Grids are of Semi Radial Squarish grid to reduce internal resistance and travel current in shorter time. Negative plates shall be heavy duty, durable flat pasted plate using lead alloy pasted Semi Negative Squarish Grid. Negative plates shall be designed to match the life of Positive plates & combination of positive & negative plates shall ensure long life, durability & trouble-free operation of battery. Computer controlled/ PLC operated in-house equipment should be deployed for preparation of lead oxide and paste to ensure consistency in paste quality & properties.

18.6.4 Containers:

The container material shall have chemical & electro-chemical compatibility & shall be acid resistant and shall conform to UL-94/ ASTM-D-2863 standard. The material shall meet all the requirements of liquid station lead-acid batteries and be consistent with the life of battery. The container shall be fire retardant and transparent. The porosity of the container shall be such as not to allow any gases to escapeexcept 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 of bulge on the sides under all working conditions. The container shall be capable of withstanding the rigorous of transport, storage and handling. The containers shall be enclosed in a steel painted tray/rack with minimum earthing provision.

For identification, each cell/module shall be marked in a permanent manner to indicate the following information:

(i) Cell Serial Number

(ii) Positive & Negative, embossed on the cover

(iii) Month & Year of Manufacturing

18.6.5 Cell Covers:

The cell covers shall be made of suitable material compatible with the container material and permanently fixed with the container by Hermetic Heat-Sealing technique. 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.

18.6.6 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 & shall have good insulating properties. Sufficient separator overlap & PVC shield protection in bottom edges of the plates is to be provided to prevent short circuit formation between the edges of adjacent plates. The design of separators shall ensure that there is no misalignment during normal operation & handling.

18.6.7 Pressure Regulation Valve:

Each cell shall be provided with a pressure regulation valve. The valve shall be self-re-sealable. The vent plug shall be made with suitable grade of fire-retardant plastic material. Each valve opening shall be covered with flame barrier capable of preventing the ingress of flame into the cell interior, when the valve opens & hydrogen/ oxygen gas mixture is released. 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.

18.6.8 Terminal Posts:

Both the +ve & -ve terminals of the cells shall be capable of proper termination & shall ensure its consistency with the life of the battery. The terminals shall have lead plated adequate solid copper/ brass core cross-section to avoid overheating at maximum current load. The surface of the terminal post extending above the cell cover including bolt hole shall be coated with an acid resistant & 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 & -ve posts shall be clearly and unambiguously identifiable.

18.6.9 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 coated 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/fumes at a very high rate of charge or discharge.

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

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

More than one cable may be required to be connected to the battery terminals. Suitable arrangement for termination of multiple cables shall be provided so as to avoid extra load on the battery terminals.

Necessary insulating supports for termination of these cables on batteries shall also be supplied by the bidder.

18.7 All cell connectors shall be capable of continuously carrying the 30 min. discharge current of the respective batteries and shall be capable to carry 4KA for 1 sec.**The inter-cell connectors shall be capable to carry minimum 10KA for 1 sec**.

18.6.10 Flame Arrestors:

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

18.6.11 Battery Bank Stand:

All batteries shall be mounted in a suitable metallic stand/ frame. The frame shall be properly painted with the acid resistive paint & should have protection against harmful effects due to tropical environment. The suitable insulation shall be provided between stand/ frame and floor to avoid the grounding of the frame/ stand. The jointing of the frames should not leave crevices and ensure proper and tight fit.

Numbering tags for each cell shall be attached to the racks. Provision for clamping outgoing cables shall be kept.

18.7. CAPACITY REQUIREMENTS:

When the battery is discharged at 10-hour rate, it shall deliver 80% of Rated Capacity (corrected at 27°C) before any of the cells in the battery bank reaches 1.85 V/cell.

The battery shall be capable of being recharged from the fully exhausted condition (1.75 V/cell) within 10hrs 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 that Rated capacity & not more that 120% of Rated capacity before any cell in the battery bank reaches 1.75 V/cell. The battery voltage shall not be less than the following values, when a fully charged battery is put to discharge at a rate of 1/10th of the Rated Capacity:

(a) After SIX minutes of discharge: 1.98V/cell

(b) After SIX hours of discharge: 1.92V/cell

(c) After EIGHT hours of discharge:1.85V/cell

(d) After TEN hours of discharge: 1.75V/cell

Loss in capacity during storage at an average ambient temperature of 35°C 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%. However, the battery to be manufactured and to be delivered at site in such a way that load can be connected with the battery within 15 days from date of installation, date of initial charging is to be mentioned on the battery.

18.8. EXPECTED BATTERY LIFE

The battery shall be capable of giving 1200 or more charge/discharge cycles at 80% Depth of Discharge at an average temperature of 27°C. 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.

18.9. ASSOCIATED EQUIPMENTS & ACCESSORIES (For each set of battery):

a)	Best quality metallic stand/frame	as per Clause 18.6.
b)	Stand insulators	+5% extra
c)	Inter row connectors	Appropriate quantity
d)	Inter tier connectors	Appropriate quantity
e)	Centre-zero (3-0-3) volts DC Voltmeter	: 1 No
f)	Torque wrench/ Spanners	: 1 No

g)	Connection hardware, such as strips, bolts, nuts	(with 5% extra)
h)	Cable clamps with hardware	
g)	Connection hardware, such as strips, bolts, nuts	(with 5% extra)
i)	Cell numbering tags with fixing arrangement	
j)	Two sets of special tools and tackles for connecting terminals of the battery	
k)	Any other accessories not specified but required for satisfactory operation.	**Free-standing portable eye wash equipment, etc.**

18.10. TYPE TEST OF BATTERY:

The Bidder/ Supplier shall supply type tested battery as per IS 15549:2004/ IEC 60896-21 & 22 over the range of at least one capacity per design. The Bidder/ Supplier shall submit necessary evidences enclosed during detailed engineering.

Sr. No.	DESCRIPTION
1	Gas Emission
2	High Current Tolerance
3	Short Circuit Current & DC Internal resistance
4	Protection against Internal Ignition from External Spark source
5	Protection against Ground Short Propensity
6	Content & Durability of required marking
7	Material Identification
8	Valve Operation
9	Flammability Rating of Material
10	Intercell Connector Performance
11	Discharge Capacity
12	Charge Retention during Storage
13	Float Service with Daily Discharge 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 Stress Temperature of 60°C for brief duration exposure time with 3hrs discharge test
17	Abusive Over Discharge

18	Thermal Runaway Sensitivity
19	Low Temperature Sensitivity
20	Dimensional Sensitivity at Elevated Internal Pressure & Temperature
21	Stability against Mechanical abuse of units during installation

18.11. Routine Test:

(i) Physical Examination Test
(ii) Visual Inspection
(iii) Dimensions, Mass & Layout
(iv) Marking & Packing

18.12. ACCEPTANCE TEST OF BATTERY

(i) Polarity Marking
(ii) Verification of Dimensions
(iii) Test of AH Capacity

LIST OF FACTORY & SITE TESTS FOR BATTERY

Sr. No	TEST	FACTORY TESTS	SITE TESTS
1	Physical Verification	YES	YES
2	Capacity Test on the cell at 1/10th of Rated Capacity, corrected at 27°C	YES	
3	8hrs Charge & 15mins Discharge Test at Full Rated Load		YES

B. BATTERY CHARGERS

18.13. SCOPE:

(i) Battery Charger for 220V/110V DC Battery Bank:

The DC system for 220V DC is unearthed. The Battery Chargers as well as their automatic regulators shall be of static type and shall be compatible with liquid station lead-acid batteries. All battery chargers **shall match with the battery** and shall be capable of continuous operation at the respective rated load in float charging mode while supplying the DC load. The chargers shall also be capable of Boost charging the associated DC battery at the desired rate.

Under normal operating conditions the charger should give a D.C. output equal to the steady demand load for signal lamps, auxiliary relays etc. plus an output to trip coils and closing coils of the circuit breakers and relays as and when required as well as float charging current of the battery. Charger shall have 20% spare capability.

(ii) Battery Charger for 48V DC Battery Bank:

The charger shall be suitable for charging the battery and supplying the load simultaneously. The entire charger scheme shall be divided in two sections, "float charger section" and "float-cum-boost charger section". The float-cum-booster charger shall be suitably operated either in float mode or in boost-cum-standby float charger mode. The float charger and the float-cum-Boost Charger shall have adjustable output current 60 Amps D.C. for 300 AH for float charging and 60 Amps DC for boost charging. Charger shall have 20% spare capability.

Under normal operating condition, with the input AC supply present, the float charger section' shall supply the DC load and also float the battery by trickle charging and the "float cum boost charger section" shall be kept off. The maximum demand load on the charger shall be 60A for 300AH Battery.

18.14. GENERAL DESCRIPTION FOR CHARGERS:

a) The 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 chargers output voltage shall remain within + 1% of the set value, for AC input voltage variation of + 10%, frequency variation of + 5% a combined voltage and frequency variation of + 10% and a DC load variation from zero to full load.

b) The 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 and designed to provide fully automatic voltage stabilization and current limitation for charging.

c) The chargers shall have load limiters having drooping characteristics, 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.

d) 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.

e) During Boost Charging, the Battery Charger shall operate on constant voltage with current limit mode (when automatic regulator is in service) to restrict battery charging current as specified. After completion of boost charging this float cum boost converter section either goes standby mode or float mode as desired by the system.

f) 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 for Float cum Boost Converter section. For Float charger section shall provide separate arrangement.

g) 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.

h) **MCCB**

All Battery Chargers shall have sufficient MCCBs on the input side to receive cables from two sources.

Mechanical interlock should be provided such that only one source shall be closed at a time. It shall be of P2 duty and suitable for continuous duty with breaking capacity minimum 25KA at 415V AC. MCCB's should have auxiliary contacts for annunciation.

i) **Rectifier Transformer**

The rectifier transformer shall be continuously rated, dry air cooled (A.N) an of class F insulation type. The rating of the rectifier transformer shall have 10% overload capacity. The transformer shall be of suitable rating to comply with maximum output with minimum input voltage.

j) **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 test acting HRC fuses shall be provided in each arm of the rectifier connections.

k) **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 of 96 mm X 96 mm square dial & shall be flush type, dust proof and moisture resistant. The instruments shall have easily accessible means for zero adjustment. The instruments shall be of 1.5 accuracy class. In addition to the above a centre zero voltmeter with selector switch shall also be provided for 220 V Chargers for testing purpose.

l) **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 V 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 be acceptable in place of Air Break Switch.

m) **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.

n) **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. All the semiconductor devices shall be protected with power transient suppressor circuit.

o) **Annunciation System**

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

(i) AC Power failure.

(ii) Rectifier/chargers fuse blown (separate for Float & Float cum boost).

(iii) Over voltage across the battery when boost charging.

(iv) Abnormal DC Bus voltage (High/Low)

(V) Charger Failure

(v) Any other annunciation if required

Potential free NO contacts of above abnormal conditions shall also be provided for common remote indication “CHARGER TROUBLE” in Owner’s Control Board. Indication for charger in float mode and boost mode through indication lamps shall be provided for chargers. A Potential free contact for float/boost mode shall be provided for external interlocks.

p) **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 ides, 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.

q). The power factor shall be better than 0.8 lagging at full load and minimum efficiency at half-load is not less than 85% at rated line voltage. It shall be ensured that the harmonics due to Silicon controlled Rectifier commutation are not reflected back into the AC power supply.

18.15. 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 enclosure shall be at least IP-42 as per IS: 13947 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. Each wire shall be continuous from end to end and shall not have any joint within itself. The insulation grade of the wiring shall be 1100 V grade. The colour of 3 Phase, 4 Wire AC. supply shall be red, yellow, blue and black for phases and neutral. The D.C. wiring shall be of the colour other than the above (preferably grey) with the +ve and -ve marking in the ferrule. All terminals shall be numbered for ease of connections and identification. Each wire shall bare 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.

18.16. Painting of Charger

The Panels shall be pre-treated using 7-Tank process and then Epoxy Powder Coated with Paint shade of RAL 7032.

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 (70) microns.

18.17. TESTS ON CHARGER

Battery Chargers shall conform to all type tests as per relevant Indian Standard. Performance test on the Chargers shall also be carried out on each charger as per specification. Rectifier transformer shall conform to all type tests in IS: 4540 and short circuit test as per IS: 2026. 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

The contractor may be required to demonstrate to the OWNER that the chargers conform to the specification particularly regarding continuous rating, ripple free output, voltage regulation and load limiting characteristic, before dispatch as well as after installation at site. At site the following tests shall be carried out: -

(i) Insulation resistance test

(ii) Checking of proper annunciation system operation

If a Charger fails to meet the specified requirements, the Contractor shall replace the same with appropriate Charger without affecting the commissioning schedule of the Sub- Station, and without any extra cost to the OWNER.

The Contractor shall present for inspection, the type and routine test certificates for the following components whenever required by the OWNER.

(i) Switches

(ii) Relays/MCCBs

(iii) Instruments

(iv) DC fuses

(v) SCR

(vi) Diodes

(vii) Condensers

(viii) Potentiometers

(ix) Semiconductor

(x) Annunciator

(xi) Control wiring

(xii) Push buttons and contactors

Makes of above equipment shall be subject to Owner's approval.

18.18. DOCUMENTATION

The successful bidder shall submit four sets of drawings for approval.

The following drawing shall be supplied with the tender: -

Outline drawings of all apparatus showing sufficient details to enable the purchaser to determine whether the design proposed can be installed satisfactorily or not. Wiring diagram of battery charger.

18.19 TECHNICAL PARAMETERS

Sl. No	DESCRIPTION	PARTICULARS
1	Type	VRLA
2	Conforming Standards	IS 15549:2004/ IEC 60896-21 & 22:2004/ BS 6290- PART IV/ IEEE-1188
3	System Voltage	220V
4	MaximumVoltageDuring Float operation	242V
5	Minimum Voltage available when no charger working and battery fully discharged upto 1.85V per cell	198V
6	Minimum no. of cell	109
7	Trickle charge voltage	2.2 V to 2.25±0.02V/cell
8	Boost charge voltage	2.23 to2.3V/cell
9	When a fully charged battery is put to discharge at a rate of 1/10th of the RatedCapacity, the battery voltage shall not be less than:	
	After SIX minutes of discharge	1.98 V/cell
	After SIX hours of discharge	1.92 V/cell
	After EIGHT hours of discharge	1.85 V/cell
	After TEN hours of discharge	1.75 V/cell
10	Battery life	1200ormorecharge/dischargecyclesat80%Depthof Discharge at an average temperature of 27°C

18.19(A): TECHNICAL SPECIFICATION FOR 220V DC BATTERY AND CHARGER

Sl. No	DESCRIPTION	PARTICULARS
1	Type	VRLA
2	Conforming Standards	IEC 60146, IEC 60478, IEC 60529, IEEE C57.12.01, ANSI C63.4, IEEE 446, NEMA
		250, NEMA PE5, NFPA 70
3	System Voltage	415V AC +/- 10% for 220V DC Battery & 240V AC +/- 10% for 48V DC Battery
4	Name of the Manufacturer	To be furnished by Bidder
5	Location of the Factory	To be furnished by Bidder
6	Type & Model of charger	To be furnished by Bidder
7	Total Dimension of Float cum Boost Charger in mm	To be furnished by Bidder
8	Minimum thickness of sheet (mm)	To be furnished by Bidder

9	Charger Characteristics	To be furnished by Bidder
10	Type of Rectifier with Model	To be furnished by Bidder
11	Capacity of Battery Charger in Amps	As per requirement
12	Float/Trickle charger current in Amps	To be furnished by Bidder
13	Boost/Quick charger current in Amps	To be furnished by Bidder
14	Voltage Regulation of Float charger (%)	To be furnished by Bidder
15	Ripple content (%)	To be furnished by Bidder
16	Schematic & GA drawings submitted	Yes/No
17	List of Alarms	To be furnished by Bidder
18	Audible noise at any point 150 centimeters from any vertical surface	Not exceeding 65dBA
19	Any other relevant information	To be furnished by Bidder

18.19 (B**):** The Battery Charger shall have Dual Source AC Input (AC Input 1 and AC Input 2) with individual MCCB and shall be provided with Auto Changeover arrangement**.**

18.19 (C): The Battery Charger shall have an IP Rating of IP42 or better. The Charger shall be type tested for IP42 or better rating.

CHAPTER 19: TECHNICAL SPECIFICATION OF POWER LINE CARRIER COMMUNICATION EQUIPMENTS WITH LINE TRAP, 48 V DC PLCC BATTERY, CHARGER

19.1 SCOPE

This specification provides design, manufacture, inspection, testing at manufacturer's works, delivery at site, installation and commissioned of indoor and outdoor Power Line Carrier Communication Equipments as specified herein for. The specification shall be complete for speech communication in dialling mode and/or through 4 wire Express Telephone, data communication and carrier aided protection for 400KV, 220KV & 132KV Transmission Lines. All communication equipment shall be suitable for good quality voice communication among new & existing Sub- Stations, reliable tele-protection and also data communication from RTU and SAS (via GATEWAY) to SLDC, Kahilipara.

19.2. SERVICE CONDITIONS

19.2.1 The materials supplied shall be suitable for operation under the climatic and other conditions mentioned in chapter 2.

19.2.2 Power Line Carrier Communication will have the following minimum components. However, for more efficient performance of the system the bidder can provide additional item at no extra cost.

a) Capacitor Voltage Transformer (CVT)

b) Wave Trap

c) PLCC Terminal

d) Line Matching Unit/ Line Matching and Distribution unit

e) Tele Protection Coupler

f) Battery and Battery charger

g) EPAX System and Telephone System

h) HF Coaxial cable

19.3 STANDARDS :

The equipment shall conform to the following latest Edition of the Indian Standards as amended up to date and as per latest relevant I.E.Cs. :

The details are given below :

1. IEC 353 for line trap
2. IS 8792 for line trap
3. I.E.C. 481 for coupling devices
4. I.E.C. 495 for power line carrier terminals
5. I.S. 8997 for coupling devices
6. I.S. 3156 for CVT
7. I.E.C. 358 for C.C. & CVT

8. I.S. 9348 for coupling capacitor
9. I.S. 11967 for Co-axial Cable
10. I.E.C. for Planning of SSB PLCC system
11. I.E.C. for Surge Arrestors
12. I.E.C. 96 for HF Cable
13. I.E.C834-I Part-I for Performance and Testing of Tele protection equipment
14. I.S. 9428 for Characteristic values of Inputs and outputs of single side band PLC terminals
15. I.S. 9528 for frequency planning of power line carrier equipment

19.4 TECHNICAL SPECIFICATION OF LINE TRAP

This specification provides for design, engineering, manufacture, stage testing, inspection and testing before dispatch, packing and delivery at destination of Line Trap along with all accessories specified herein. The line trap to be inserted into high voltage A.C transmission lines to prevent undue loss of carrier signal power, typical in the range 30KHz to 500KHz, under all power system conditions and to minimize interference from carrier signaling systems on adjacent transmission lines.

19.4.1 STANDARDS:

Unless otherwise specified elsewhere in this specification, the rating as well as performance and testing of the line trap shall conform but not limited to the latest revisions and amendments available at the time of placement of order of all the relevant standards as listed hereunder.

Sl No	Standard No.	Title
1	IEC 60353 Second edition, 1989-90	Line Trap for AC Power System
2	IS : 8792-1978	LINE TRAPS FOR AC POWER SPECIFICATION SYSTEMS -(First Revision)
3	IS : 8793-1978	LINE TRAPS FOR AC POWER SPECIFICATION SYSTEMS METHODS OF TESTS -(First Revision)
4	IS-9859 (PART-I)-1981	CODE OF PRACTICE FOR INSTALLATION AND MAINTENANCE OF OUTDOOR POWER LINE CARRIER EQUIPMENT PART I LINE TRAPS (Incorporating Amendment No. 1)
5	IEC 99	Lightning Arresters
6	IEC 99 - 1(1970)	Part-1 , Non-Linear resistor type arresters for

		AC systems
7	IEC 60099-4/2006	Metal-oxide surge arresters without gaps for a.c. systems
8	IS : 5561-1970	Terminal Clamp / Connector

19.4.2 PRINCIPAL TECHNICAL PARAMETERS FOR LINE TRAP:

The Line Trap covered in this specification shall meet the technical requirements listed hereunder. Line traps of different voltage rating shall conform to the following technical particulars:-

TABLE- I

Sl No	Technical Parameters	VOLTAGE LEVEL		
		400KV	132 kV	220 kV
I	II	III	IV	V
2	Type of mounting	Pedestal	Suspension /Pedestal	Pedestal
3	Suitable for system Frequency	50 Hz	50 Hz	50 Hz
4	Nominal System Voltage	400KV	132 KV	220 KV
5	Highest System Voltage	420KV	145 KV	245 KV
6	Rated Continuous Current	3150A	800 A	1250 A
7	Rated Short time current for 3 second	63KA	40 kA	50 KA
8	Asymmetrical peak value of the first half wave of the rated short time current	127.5 KA	51 KAp	102 KAp
9	Rated inductance	1 mH	0.5 mH	0.5 mH
10	Type of Tuning	Broad Band	Broad Band	Broad Band
11	Blocking Band frequency range	90-150Khz 150-500Khz	90-150Khz 150-500Khz	90-150Khz 150-500Khz

12	Minimum Guaranteed resistive component of impedance in Blocking Frequency range	500 Ohm	570 ohm	570 ohm
13	Protective device	a) Non-linear resistive type Gapped lightning arresters for a.c. system	a) Non-linear resistive type Gapped lightning arresters for a.c. system	a) Non-linear resistive type Gapped lightning arresters for a.c. system
14	Nominal discharge current of protective device	10KA. However, Coordination shall be done by taking 20KA 8/20 micro-sec discharge in to consideration.	10 KA	10 KA
15	Rated voltage of protective device	> 15.72 KV rms	4.5 KV	9 KV
16	Minimum value of power frequency spark over voltage (Dry and wet) of protective device	> 23.58 KV rms	6.75 KV rms	13.5 KV rms
17	Visual corona extinction voltage	320 KV rms	97 KV rms	156 KV rms
18	Radio Influence Voltage (RIV)	< 500 micro Volt @ 280KV.	< 500 micro volt	< 500 microvolt
19	Attenuation in tuned frequency band	> 7.5 dB	>7.5 dB	>7.5 dB
20	Maximum tapping loss over blocking band I & II stated bove above	2.6 dB	2.6 dB	2.6 dB
21	Maximum tapping loss based on blocking resistance	2.6 dB	2.6 dB	2.6 dB
22	Insulation class	Class F Insulation	Class F	Class F
23	Maximum working stress	Twice the weight of wave trap + 500Kgs.	Twice the weight of wave trap +	Twice the weight of wave trap +

			500 Kgs	500 Kgs

19.4.3 GENERAL TECHNICAL REQUIREMENTS:

A line trap, consisting of a main coil in the form of an inductor, a tuning device and a protective device, is intended for insertion in a high voltage power transmission line between the point of connection of carrier frequency signals and adjacent power system elements such as busbar, transformers etc. The tuning device connected across the main coil ensures, with proper adjustment, that the line trap presents relatively high impedance at one or more carrier frequencies or carrier frequency bands, whereas the impedance of the line trap at power frequencies is negligible. A line trap may also be used to limit the loss of carrier-frequency at a power system tee point.

19.4.3.1 Main Coil:

An inductor carries the power frequency current of the high voltage transmission line. Wave trap shall consist of a main coil designed to carry continuously the rated current at the maximum ambient temperature and at full operating line voltage. It shall be supplemented with a protective device and a tuning device.

19.2.3.1.2 Tuning Device:

Line traps are to be tuned for a carrier frequency band, which will depend upon the operation carrier frequency pair chosen for transmission lines in question. The resistive component of impedance of the wave trap within its band shall not be less than 570 ohms. The wave traps should be provided with suitable barriers to prevent the entry of birds into the same.

19.4.3.2 Protective Device:

The device connected across the main coil and tuning device which prevents the line trap from being damaged by transient over voltages which may occur across it. The protective device shall be so designed and arranged that neither a significant alteration in its protective function nor physical damage shall result either from the temperature rise or magnetic field of the main coil at continuous rated current, rated short-time current or from emergency overload current. It shall neither enter into operation as a result of the power frequency voltage developed across the line trap by rated short time current nor shall it remain in operation after a response to a transient over voltage which is immediately followed by the power frequency voltage developed across the line trap by rated short-time current.

The protective device shall be shunt connected to the main coil and the tuning device.

For proper coordination with the lightning arrester installed in the substations and generating stations, the wave traps shall be provided with protective device with nominal discharge current of 10 KA.

19.4.4 DESIGN REQUIREMETS:

Ability to withstand rated short-time current: The line trap so designed shall be capable to withstand the mechanical forces produce by asymmetrical peak value of the short-time current.

19.4.5 Insulation level:

The insulation level for the insulation between the terminals of a line trap is governed by the rated voltage of the protective device. The insulation of the main coil and the tuning device shall be adequately rated for:-

a) The voltage developed across the line trap at the rated power frequency by the rated short-time current. The rated voltage of the protective device shall be higher than this voltage developed across the line trap.

b) the front of wave impulse spark over voltage or the residual voltage caused by the nominal discharge current of the protective device, which ever is higher.

19.4.6 System Voltage insulation:

The system voltage insulation of a line trap is provided by insulator strings or post insulators. The line trap system voltage insulation shall be consistent with the other equipment in the associated high voltage transmission network.

19.4.7 Tensile strength of suspension system:

The suspension system of a line trap shall be designed for a tensile stress of at least twice the mass of the line trap in kilograms, multiplied by 9.81 to convert to newtons, plus 5000 N.

19.5 ACCESSORIES:

i) **Bird barriers**: The bird barrier design shall be such that no entrance to the line trap shall admit a sphere having a diameter of 16 mm.

ii) **Terminal clamp/connectors**: The clamp shall be suitable for AAAC/ACSR Zebra conductor in case of 220 kV system and AAAC/ACSR Panther conductor in case of 132 kV system. The clamp, connectors, nuts, bolts and hardware shall be of nonmagnetic material and shall conform to IS: 5561. The clamp shall be fitted on incoming and outgoing pad of Line Trap. The incoming and outgoing conductor shall be on either side of the clamp fitted with the help of bolts and nuts arrangements. The clamp shall be designed to carry the continuous load of 800 Amp at 132 KV and 1250 Amp at 220 KV and shall withstand a dynamic short circuit current of 31.5 and 40 KA respectively for 1 second. The temperature rise shall not exceed 35°C over 50°C ambient. All the castings shall be free from blowholes, surface blisters, cracks and cavities. All sharp edges shall be blurred, rounded off and buffed. Clamp and connectors shall be designed to avoid corona formation. The visual corona extinction voltage shall not exceed 97 KV (rms.) for 132 kV and 156 kV (rms) for 220 kV. Radio interference voltage for clamp and connectors shall not exceed 500 microvolts at 97 KV (rms.) for 132 kV and 156 kV (rms) for 220 kV. No current carrying parts of the Clamps and connector shall be less than 10 mm of thickness.

iii) **400KV WAVE TRAP**

The clamp shall be suitable for 4” IPS AL TUBE and TWIN/QUAD ACSR Moose Conductor. The clamps shall be chosen as per requirement of the substation. The clamp, connectors, nuts, bolts and hardware shall be of non-magnetic material and shall conform to IS: 5561. The clamp shall be fitted on incoming and outgoing pad of Line Trap with four Nos. of Nuts & Bolts. The incoming and outgoing conductor shall be on other side of the clamp fitted with the help of six bolts and nuts arrangements. The clamps shall be suitable for horizontal and vertical take off with conductor diameter 31.77 mm for Twin/Quad ACSR Moose conductor. The clamp shall be designed to carry the continuous load of 3150 Amp at 400KV and shall withstand a dynamic short circuit current of 50KA for 3 second. The temperature rise shall not exceed 35 °C over 50 °C ambient. All the castings shall be free from blowholes, surface blisters, cracks and cavities. All sharp edges shall be blurred, rounded off and buffed. Clamp and connectors shall be designed so as to avoid corona formation. The visual corona extinction voltage shall not exceed 320 KV (rms.). All nuts and bolts shall be suitably shrouded. Radio interference voltage for clamp and connectors shall not exceed 1000 microvolt at 305 KV (rms.) at 1 MHz. No current carrying parts of the Clamps and connector shall be less than 10mm thickness including drilled Holes.

iv) RATING PLATES:

The main coil, the tuning device and the protective device shall be provided with rating plates of weatherproof material fitted so that they are readily visible. .

v) **Line Trap:**

The Line Trap shall be supplied with fitted Tuning Pot and Lightning Arrester. All the type test reports as per relevant IS/IEC of the Line Trap offered shall be invariably enclosed with the offer. Offers without Type Test Report shall not be considered. The Line Trap shall be fitted with top and bottom clamp with Connector etc. complete in all respect for connecting line trap to line side and equipment side respectively. The clamp, connector, nut, bolts, etc. which is affected by magnetic field of line trap shall be of nonmagnetic material. All iron parts shall be hot dip galvanized. The arrangement of minimum three nos. of tie rod assembly shall be required to avoid shearing from thread of tie rod assembly.

19.6 DRAWINGS:

The following drawings indicating all the dimensions etc. with complete technical details shall be enclosed together with technical bid :

(i) General arrangement for Line Trap indicating dimensions, technical parameters, weight etc

(ii) Suspension / mounting arrangement indicating dimensions

(iv) Tuning pot ckt arrangement

(v) Details of terminal clamp/connectors suitable for AAAC/ACSR conductor and quac/twin ACSR Moose conductor

(viii) Suspension fittings (hardware) for line trap

(ix) Disc Insulator with general technical specification

(x) Lightning Arrestor as protective device for Tuning Pot

(xi) Bird barriers

(xii) Other accessories of Line Trap

(xiii) Any other components/drawings not covered

19.7 TECHNICAL SPECIFICATIONS OF LINE MATCHING UNIT/LINE MATCHING DISTRIBUTION UNIT (LMU/LMDU):

19.7.1 GENERAL REQUIREMENT:

The indoor PLCC equipments are connected to line through co-axial cable – outdoor coupling device – Coupling Capacitors for transmission & reception of carrier frequency signals. Coupling devices are connected in between HF terminal of Coupling Capacitor and indoor PLCC terminals through co-axial cable.

The coupling device proposed to be procured shall perform following functions as a composite unit:

1. Compensate the reactive component of coupling capacitor(s) impedance in order to efficiently transmit the carrier signals with the help of tuning device.
2. It shall match the impedance between power line and coaxial cable end.
3. Two numbers 'phase to earth' type coupling filters shall be used to achieve 'phase to phase'/ ' Inter-circuit coupling'. Connection between secondaries of the two phase to earth type coupling device shall be through a balancing transformer/hybrid such that reliable communication shall be ensured even when one of the coupled phase is earthed or open circuited on the line side.
4. Galvanic isolation of primary & secondary terminals of coupling device.
5. It shall drain the power frequency current derived from coupling capacitor(s) to earth.
6. It shall arrest the voltage surges received from power line at the terminal of coupling device.
7. It shall provide direct & efficient earthing to primary terminals of the coupling device. The equipments shall be of latest components, technology and highly reliable. The equipments offered must have been type tested.

19.7.2 SCOPE OF SUPPLY:

Line Matching Unit / Line matching Distribution Unit shall be supplied fully wired complete in all respect with all interconnections and coaxial cable termination facilities with UHF glands. The equipment shall be of latest design with modular construction.

19.7.3 SPECIFICATION:

(a) STANDARDS :

The coupling device offered shall confirm to following standards:

1. IS 8997: Specification for coupling devices for PLC system
2. IEC 481: Coupling devices for power line carrier system
3. IS 8998: Methods for tests for coupling devices for PLC System

(b) CONSTRUCTION:

The coupling device offered shall be fully programmable.

The Unit shall be modular in design and should accommodate tunable modules for different use. The bidder will furnish the details of tunable modules, which can be used along with the device. The composite unit shall be housed in waterproof Fibre Box modular construction cabinet with proper ventilation & vermin proofing arrangement. Proper arrangement for mounting the same on G. I. supporting structure shall be made. The equipments shall work satisfactorily under hot humid & polluted atmospheric conditions. Suitable arrangements shall be provided for the connection of co-axial cables in the coupling device and supply of cable connectors shall be in the scope of supply. Cable glands of good quality suitable for co-axial cables shall be provided.

19.7.4 FEATURES:

1. The coupling device offered shall be suitable for nominal equipment side impedance of 75 ohms unbalanced and 150 ohm balanced as required.

2. The equipment offered shall work satisfactorily for carrier frequency range of 50-500 KHz.

3. The line side impedance shall be 200 Ohms to 400 Ohms for phase to earth couplings and 400 ohms to 600 ohms for phase to phase coupling.

4. The coupling device shall be suitable for use with coupling capacitor of 2200 to 8800 pf and shall be programmable.

5. Insulation withstand voltage shall be 10 kV RMS for one minute.

6. Impulse withstand voltage for high voltage input side to ground shall be 10 kV and co-axial cable input to ground shall be 3 kV.

7. The nominal peak power of the coupling device shall not be less than 1000W.

8. The coupling device shall have inbuilt three element protective device consisting of drainage coil, Lighting Arrestor and Earthing Switch confirming to relevant standards. The same shall be generally meet the following requirements:

(a) Drainage Coil: The drainage coil shall effectively ground the 50Hz power frequency current received from coupling capacitor(s) but shall not permit HF signal to ground. The power frequency impedance shall be less than 1.5 ohm and continuous current capacity at power frequency shall be 1.5Amp.

(b) Lightning Arrestor: The lighting arrestor shall effectively ground the high voltage surges coming from power line side at the terminal of coupling device. The lighting arrestor shall stand spark over voltage of 3.3 kV.

(a) The Earth Switch: The earthing switch shall ground the primary terminal of coupling device when required. The rated current for earthing switch shall not be less than 150 Amp.

9. The interconnections in the coupling device shall be made with special high frequency Liz wires.

10. The impedance matching shall be prefect so that the return loss is minimum.

19.7.5 TYPE TESTS:

Valid Type Test reports not more than 5-Year-old performed for following tests along with all test result sheets & reference documents shall be submitted with the offer here under.

- Composite Loss
- Return Loss
- Distortion & Intermodulation

- Lightning Impulse Voltage Withstand
- Power frequency Voltage Withstand
- Drain Coil
- Environmental test
- Degree of protection : IP 55
- Earth switch

19.7.6 TECHNICAL PARTICULARS FOR MODULAR COUPLING DEVICE

TABLE-II

Sl No	Description	COUPLIND DEVICE
1	Carrier Frequency Range	78-500 kHz
2	Maximum temperature limit for satisfactory operation of coupling device mounted outdoor	**50^0 C or better**.
3	Composite loss	≤ 1 dB
4	Return loss	≥ 12 dB
5	Nominal line side impedance	240/320 ohms (Phase to earth)
6	Nominal carrier equipment side impedance	75ohms unbalanced and 150 ohm balanced, 75ohms unbalanced and 150 ohm balanced (switchable)
7	Nominal Peak Envelop power with Distortion and Inter-modulation Products 80 dB Down)	1000 watts for frequency≥100 kHz
8	Power frequency Impedance between primary terminal and Earth Terminals of Coupling Device	Less than 20 ohm
9	Maximum number of PLC terminals that can be connected in parallel	
	(a) 20 W (P.E.P) PLC Terminals	(a) 8 to 12 nos.
	(b)40 W (P.E.P.) PLC Terminals	(b) 6 to 8 nos.

	(c) 100 W (P.E.P.) PLC Terminals	(c) 4 to 6 nos.
10	1 Minute Power Frequency Insulation level between Primary and Secondary Terminals of Coupling Device	10 KV rms
11	Impulse (1.2/50 micro-sec) withstand level between Primary and Secondary Terminals of Coupling Device	10 kV peak
12	Drainage Coil :	
13	(a) Inductance	0.2 to 0.7 mH
	(b) Continuous power frequency current	≤ 1.5 Arms
	(c) Short time rating for 0.2 sec	≤ 50 A
14	Lighting Arrestor :	
15	(a) Type of construction	Non linear resistor type with spark gap
	(b) Rated Voltage	660 V
	(c) Rated discharge current	5 KA_{peak}
	(d) Maximum permissible short time current	30 kA peak
	(e) Impulse spark over voltage (max)	3300 V_{peak}
16	Earthing Switch	
	(a) Rated Current	250 $A_{rms,}$ or better
	(b) Rated Voltage	10kV
	(c) Short time current	16 kA, 1 sec

19.8 Technical Specifications Digital Power Line Carrier Equipment

19.8.1 General

Power Line Carrier (PLC) System will primarily be used for tele-protection, voice & data communication. The new Power Line Carrier (PLC) circuits in conjunction with existing OPTICAL communication network shall connect the new SAS networks (IEC61850) of existing and new 132KV/220 KV/400KV substations of AEGCL via GATEWAY as per IEC60870-5-101 and IEC60870-5-104 to the nearest Wideband nodes connected to SLDC, Kahilipara for data communication. Digital PLCC (twin channel, 8kHz bandwidth) equipment shall be procured under this project. DPLC shall be applied in analog mode via FSK channels or in digital mode via the implemented data pump to transmit SAS information. For 400kV Lines, bidder shall quote two PLCC Panels for each line where one panel will be for transmission of Speech + Data and the other panel will be for dedicated carrier inter tripping scheme.

19.8.2 The PLC equipment shall comply with the standard IEC 60495, second edition, 1993.

19.8.3 For safety, the equipment shall conform to IEC 60950-1, 2005.

19.8.4 For EMC and EMI, the equipment shall comply with IEC 61000-6-2(Immunity) and IEC610006-6-4 (Emission). In particular, it shall comply with IEC 60255-5, IEC 61000-4-2/-3/-4/-5/-6/-8/-12/-16/-17/-18, IEC 60255-22-1, EN 55022 / CISPR22.

19.8.5 The system shall be of modular design and allow for easy upgrading.

19.7.6 The PLC equipment shall not use fans or similar for artificial cooling under normal operating conditions.

19.7.7 Carrier frequency section

19.7.7.1 The PLC equipment shall support DPLC (Digital PLC) and APLC (Analog PLC) mode of operation in the same platform, software programmable via PC/Notebook.

19.7.7.2 Modulation shall be SSB (Single-Side-Band) for APLC operation MCM(Multi-Carrier- Modulation) with Trellis Coding for DPLC mode operation.

19.7.7.3 Modulation and coding shall be implemented as software functions in DSP (Digital Signal Processor) technology.

19.7.7.4 Transmission mode shall be 2-wire frequency duplex.

19.7.7.5 The nominal carrier frequency shall be programmable from 40 kHz to 500 kHz minimum, preferably however up to 1000 KHz for nominal band widths ≥ 4 kHz.

19.7.7.6 The carrier frequency stability over the stated temperature operating range shall be equal or better than +/- 1 ppm.

19.7.7.7 The nominal bandwidth BN for transmitting or receiving shall be programmable from 4 kHz to 32 kHz in steps of 4 kHz, and to 2 kHz or 2.5 kHz (for single purpose tele protection).

19.7.7.8 Transmit (Tx) and receive (Rx) bands shall be configurable for adjacent or non- adjacent operation.

19.7.7.9 Transmit output power shall be user-programmable through software up to 100 W or more (Peak Envelop Power) to maintain healthy link for line length of at least 250 km. The output power shall be reducible in steps of 1 dB via user interface program (HMI).

19.7.7.10 The nominal output impedance shall be 75 Ohm unbalanced or 150 Ohm balanced as an option.

19.7.7.11 The return loss in the transmit band shall be ≥ 10 dB, according to IEC 60495.

19.7.7.12 The tapping loss shall be ≤ 10 dB, according to IEC 60495.

19.7.7.13 The receiver selectivity shall be > 65 dB at 300 Hz from the band edges.

19.7.7.14 The AGC range of the receiver shall be 40 dB minimum or better to maintain healthy link for line length of at least 250 km.

19.7.7.15 **The supplied PLCC Equipment should be in successful operation for at least 3 years for a line length of Minimum 250 km at 400kV or above voltage level. The bidder shall submit the relevant Performance Certificate from STU/CTU at the time of Bidding.**

19.8 System Operation

19.8.1 The PLC shall be programmable via PC with HMI/GUI (Graphical User Interface) based on MS-Windows.

19.8.2 The PLC system shall facilitate the programming and monitoring of the remote terminal from the local terminal using the standard GUI/HMI (Human-Machine-Interface).

19.8.3 An EMS (Element Management Service) shall be incorporated in the HMI for monitoring and programming of the PLC terminals in the network. The EMS shall allow remote cyclic alarm polling of all the PLC terminals in a network.

19.8.4 Supervision of a PLC network shall optionally be possible using SNMP (Simple Network Management Protocol), serving communication network management systems with alarm and equipment information.

19.8.5 Remote access to the equipment over IP networks shall make use of the SSL/TLS protocol for secure communication. Equipment internal user authentication and logging of security relevant data shall be supported.

19.8.6 Command and alarm events as well as special system events (e.g. equipment reset) shall be stored by an internal event-recorder in a non-volatile memory. At least 1000 command events and another 1’000 alarm/system events shall be recordable. The latest 1000 events of each type must always be available, even in case of a memory overflow.

19.8.7 A clock synchronizing input shall be provided, to synchronize the internal real time clock with the external Station GPS signal. The DPC Panel should have interface for sync with the station GPS Clock. Furthermore, the Bidder shall ensure that the remote end stations, to be connected via PLCC Link, have the necessary equipment and interfaces for synchronizing the internal real time clock of DPC panel with the station GPS and shall ensure the same by providing any additional equipment (if required) without any cost implication to AEGCL. The Bidder may carry out the necessary survey for the same before the submission of the BID.

19.8.8 Back-up batteries for preserving the data (configuration, event recorder, etc.) during loss of supply are not accepted.

19.8.9 The Workstation or PC/Notebook shall be connectable via a serial RS-232 port (converter shall be provided for serial to USB) or via Ethernet/IP port(s). The bidder should provide serial to USB converter for each supplied PLCC Panel as a mandatory accessory.

19.8.10 With the Ethernet/IP interface option it shall be possible to access the PLC terminal via LAN intranet.

19.8.11 The PLCC/ DPC should be integrated with an external counter for display of any executed inter tripping commands.

19.8.12 The PLCC Panel supplied should be equipped with redundant power supply and CPU Card.

19.4.9 **Speech and Audio Frequency (AF) signal transmission**

19.4.9.1 The PLC shall be configurable for providing up to 3 analog AF (audio-frequency) channels with 4 kHz gross bandwidth each.

19.4.9.2The useful frequency band shall range from 300 Hz to 3720 Hz for each AF channel.

19.4.9.3For each channel, a speech low-pass filter shall be configurable with a programmable upper cut-off frequency, ranging from 2 kHz to 3.4 kHz in steps of 200 Hz.

19.4.9.4Speech interfaces shall be configurable as 4-wire E&M, 2-wire FXO and 2-wire FXS.

19.4.9.5It shall be possible to configure 3 analog speech channels in 8 kHz or in 12 kHz RF-transmission bandwidth.

19.4.9.6Inter-channel crosstalk shall be compliant with IEC 60495.

19.4.9.7A compandor according to ITU-T G.162 shall be configurable via HMI for each speech channel. Control inputs shall be provided for compandor switching (on/off) by the PABX.

19.4.9.8The frequency band above speech shall be available for the transmission of narrowband modem signals from internal or external modems.

19.4.9.9The level range of the AF-input/output ports shall be in accordance with IEC 60495.

19.4.9.10 Digital transit filters, programmable with respect to bandwidth and center-frequency in steps of 60 Hz, shall be available for each AF channel for the local extraction, insertion and transit-connection of selected teleoperation frequency bands.

19.4.9.11 An equalizer shall be available for each AF channel for equalizing amplitude response distortions of up to +/- 12 dB.

19.4.9.12 The equalizer shall also be configurable for equalizing group delay distortions of up to 2 ms.

19.4.9.13 The frequency response before and after equalization shall be displayed in graphical form by means of the GUI (HMI).

19.4.9.14 Equalization of the channel frequency response in both directions shall be possible from one (either) end.

19.4.9.15 Integrated Digital Compressed Voice shall be available as an option. Up to 16 digital compressed speech channels shall be supported per PLC link.

19.4.9.16 The data rate required for one compressed speech channel shall be less than 7 kbit/s.

19.4.9.17 In a substation, selected compressed voice channels shall be through connectable on a digital basis to other PLC terminals/links.

19.4.10 **Narrowband Data Transmission**

19.4.10.1 The PLC shall provide - as software options – up to four integrated modems for narrowband data transmission.

19.4.10.2 Transmission speed, channel center-frequencies and the spectral bandwidth shall be programmable in steps for commonly used data rates, ranging from 100 bit/s to 9600 bit/s in bandwidth of 240 Hz to 3400 Hz respectively.

19.4.10.3 The narrowband modems shall be designed for low delay and short recovery times following a link disturbance.

19.4.10.4 Adaptive equalizers, individually configurable for each narrowband modem, shall ensure optimum performance over time, by compensating changing channel characteristics. In a 4 kHz channel, it shall be possible to transmit up to 4 x 2400 bit/s, or 2 x 4800 bit/s, or 1 x 9600 bit/s.

19.4.10.5 Data transmission above 2 kHz band-limited speech shall be possible at 2 x 2'400 bit/s or 1 x 4'800 bit/s.

19.4.11.0 **Broadband Data Transmission**

19.4.11.1 The PLC shall provide – as software option – an integrated modem for broadband / high speed data transmission. Transmission speed and spectral bandwidth shall be programmable via PC/Notebook.

19.4.11.2 The speed and transmission bandwidth shall be programmable for up to 32 kbit/s in 4 kHz spectral bandwidth, up to 128 kbit/s in 16 kHz bandwidth and up to 256 kbit/s in 32 kHz bandwidth.

19.4.11.3 The data rates shall be selectable in steps, compliant with commonly used standardized data rates.

19.4.11.4 The system shall support automatic transmission speed adaptation in five user-defined steps, self-adapting to the prevailing line condition (noise and interference).

19.4.11.5 The broadband modem shall provide a facility for automatic detection and suppression of narrowband interferers.

19.4.11.6 Special operating modes shall allow transferring analog speech (with an upper cut-off frequency of 2 kHz) and a broadband modem (operated in the frequency band above 2 kHz) in channels with nominal bandwidth BN of 4 kHz and 8 kHz. The data rate of the broadband modem using the remaining 2 kHz bandwidth shall be at least 9.6 kbit/s, the data rate of the broadband modem using the remaining 6 kHz bandwidth shall be up to 48 kbit/s.

19.4.12.0 **Data Multiplexing**

19.4.12.1 The PLC equipment shall provide an internal multiplexer for the time-division multiplexing of up to 6 serial data channels and/or Ethernet/IP traffic.

19.4.12.2 Data ports shall be compliant with V.24/V.28, RS-232 and/or V.11/X.21/X.24.

19.4.12.3 The internal multiplexer shall provide data flow control for the asynchronous ports and speed adaptation for the synchronous ports according to the prevailing aggregate data rate and HV power line condition.

19.4.12.4 All data ports shall be electrically isolated from ground and against each other.

19.4.12.5 Point-point and point-multipoint operation with channel-sharing shall be possible, for polling SCADA protocols.

19.4.12.6 Three Ethernet/IP ports - electrical 10/100 Mbit/s, auto sensing - shall be available as an option. Preferably, a fourth port with exchangeable SFP transceivers for optical connection shall be provided.

19.4.12.7 The Ethernet/IP ports can be used for equipment programming & monitoring and/or for Ethernet/IP traffic switching/routing via the PLC link. No external device(s) shall be required for the latter purpose.

19.4.12.8 IP header compression shall be configurable in order to minimize bandwidth.

19.4.12.9 In switching mode, VLAN support shall be configurable (ID & priority). In routing mode, ≥ 10 IP routes and port-based priority shall be configurable.

19.4.12.10 The bandwidth of the Ethernet/IP service via the PLC link shall follow the automatic speed adaptation of the broadband modem.

19.4.12.11 SALIENT FEATURES OF DIGITAL PLCC

The salient features for the Digital PLCC are detailed out as follows

A. HIGH FREQUENCY CHARACTERISTICS

1. Frequency Range	40-500 KHz as per IEC 60495
2. Center Frequency Programmable	In steps of 1 Hz
3. Nominal Impedance	75 ohm unbalanced (150 ohm balanced as an option)
4. Return Loss in the transmitted band	≥10 dB according to IEC 60495
5. Tapping loss	≤ 1.5 dB according to IEC 60495
6. Image rejection	≥75 dB

B. TRANSMITER / RECEIVER

1. Nominal transmit output power (PEP)	upto 100W or better
2. Nominal Bandwidth	4- 32 kHz (each direction)
2. Output Level Adjustment	In steps of 1 dB (via user interface program (HMI))
3. Receiver Sensitivity	-30 dBm
4. Receiver Selectivity	As per IEC-60495
5. AGC Range (Automatic Gain Control)	40 dB dynamic range or better
6. Minimum Signal to Noise Ratio	20dB(QAM16/TCM32)/24dB(QAM64/TCM128)

C.GENERAL CHARACTERISTICS

1. Application	Universally applicable in analog, digital, or mixed operation.
2. Modulation	Single Side Band with Suppressed carrier SSB) Multi-Carrier (OFDM) modulation with Trellis Coding and forward error correction. Single step frequency conversion with Direct Digital Synthesis (DDS).
3. Gross Bit rate	32 kbps in 4 kHz, 128 kbps in 16 kHz up to 256 kbps in 32 kHz bandwidth
4. Test Facilities	Inbuilt accessible via HMI

5. Standards compliance	IEC 60495, IEC 60834-1, IEC 60950-1, IEC 61000-6-2, IEC 61000-6-4

D. USER INTERFACES

1. Data Interfaces and bit rates supported	RS- 232 (up to 19.2 kbps)/V.24
	Ethernet, V.11
2. Voice interfaces supported	2W/4W E&M, FXO and FXS, Hotline
3. Speech level adjustment	Transmit level (-20 to + 5 dBm)
	Receive level (-20 to + 8 dbm)

E. OTHER CHARACTERISTICS

1. Alarms	Supported on panel
2. Operating Temperature and humidity	0 to +45 deg C, 90% humidity
3. Power supply voltage	48 VDC +20/- 15%
4. Maximum power consumption	135 W or better for normal operation @ 75 Ohm

19.5.0 TECHNICAL SPECIFICATION OF TELE-PROTECTION COUPLER

19.5.1 The Digital protection signalling equipment is required to transfer the trip commands from one end of the line to the other end in the shortest possible time with adequate security and dependability. It shall also monitor the healthiness of the link from one end to the other and give alarms in case of any abnormality. The protection signalling equipment shall have a proven operating record in similar application over EHV systems and shall operate on 48V DC (+15%, -10%).

It shall provide suitable interfaces for protective relays, which operate at 220/110V DC. Power supply points shall be immune to electromagnetic interface.

19.5.2 Principle Of Operation

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

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

19.5.3 Loop Testing

An automatic loop testing routine shall check the tele protection channel.

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

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

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

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

- Shall work in Digital PLCC Terminal.
- Full Duplex operation
- Auto loop facility shall be provided
- Shall be able to transmit upto 4 commands with trip counter

Bidder shall quote for protection signalling equipment suitable for 4 commands with separate trip counters for transmit and receive. Laptop shall be provided for configuration of PLCC/DPC.

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

The DPC shall be housed in offered PLCC panel and should be a standalone type.

Reports of the following tests shall be submitted for approval for protection signalling equipment and relays associated with the protection signalling equipment and interface unit with protective relay units, if any.

i) **General equipment interface tests :**

a. Insulated voltage withstand tests

b. Damped oscillatory waves disturbance test

c. Fast transient bursts disturbance test

d. Electrostatic discharge disturbance test

e. Radiated electromagnetic field test

f. RF disturbance emission test

ii) **Specific power supply tests**

a) Power supply variations

b) Interruptions

c) LF disturbance emission

d) Reverse polarity

iii) **Tele-protection system performance tests**

a) Security

b) Dependability

c) Jitter

d) Recovery time

e) Transmission time

f) Alarm functions

g) Temperature and Humidity tests (As per IEC 68-2)

a. Dry heat test (50°C for 8 hours)

b. Low temperature test (-5°C for 8 hours)

c. Damp heat test (40°C/95%RH for 8 hours)

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

iv) Relays

a) Impulse voltage withstand test as per IEC 60255.

b) High frequency disturbance test as per IEC 60255.

19.5.4 The bidder shall offer voice frequency transmission equipment, which shall work on frequency shift or coded signal principle for transmission/ reception of protection signals.

19.5.5 The teleprotection shall conform to IEC 60834-1, 1999.

19.5.6 Each teleprotection system shall support the transmission of up to four independent and simultaneous commands, programmable individually for blocking, permissive tripping or direct tripping (intertripping).

19.5.7 The transmission of the command signals shall be accomplished within the speech bandwidth or within the spectral bandwidth of the broadband modem, i.e. the teleprotection shall not require the allocation of extra / separate bandwidth.

19.5.8 During transmission of protection commands, other services like speech and data shall be temporarily interrupted in order to transmit the protection signal at increased power (command signal boosting).

19.5.9 The nominal transmission time shall be < 11 ms, < 12 ms and < 13 ms for blocking, permissive tripping and direct tripping respectively.

19.5.10 The equipment for protection shall have high degree of reliability and speed. It shall be guaranteed to function reliably in the presence of noise impulse caused by isolator or breaker operation. The required SNR shall be less or equal than 6 dB for a dependability of < 1E-03 for blocking and permissive tripping, and for a dependability of < 1E-04 for direct tripping, i.e. the probability of missing a command in a maximum actual transmission time Ttr = 15 ms, 17 ms and 22 ms respectively.

19.5.11 The probability of an unwanted command (security) shall for any SNR condition (worst case) be not higher than 1E-03, 1E-06 and 1E-09 for blocking, permissive tripping and direct tripping respectively.

19.5.12 Electrically isolated opto-coupler inputs, solid-state outputs shall be available as I/O interfaces to the protection devices. Voltage range shall be selectable from 24 VDC to 250 VDC nominal.

19.5.13 Commands shall be freely allocatable to the inputs and the outputs, alarms shall be freely allocatable to the outputs (programmable via HMI).

19.5.14 It shall be possible to individually delay and prolongate the input command signals or to prolongate the output command signals and to monitor their duration (all parameters configurable via HMI).

19.5.15 All transmitted and received commands shall be logged with time stamps of 1 ms resolution by the internal event-recorder.

19.5.16 The teleprotection shall provide an integrated cyclic loop test.

19.5.17 The teleprotection shall be software-programmable via PC HMI with GUI.

19.5.18 For single-purpose teleprotection applications, the nominal transmission bandwidth of the PLC terminal shall be configurable for 2 kHz or 2.5 kHz in each direction. A service phone channel shall optionally be available in this operating mode.

19.5.19 The DPC should have E1 interface so that two channels can be created for transmission of commands, out of which one channel will be through PLCC and the other channel through FOTE. The channel arrangement should be such that if the main channel fails, the DPC should automatically switch to the other channel.

19.5.20 The offered DPC shall be equipped with redundant Power Supply Card and redundant 4 command Relay Interfacing card.

19.5.21: The DPC shall be IEC 61850 compliant Digital Tele- Protection Coupler, have 16 commands with redundant power supply card and CPU along with Analog PLCC Interface Card, E1 interface card and optical interface card to support 150 km for 132kV and 220kV and 240km for 400kV

19.5.19 PRINCIPAL TECHNICAL REQUIREMENTS OF TELE PROTECTION COUPLER

TABLE-III

Application	Transmission of protection commands for line and objects protection via DPLC equipment.
Number of units	Two No, 8 commands (atleast) module to be fitted in offered DPC (Standalone)
Number of commands	16 simultaneous commands per system, simultaneously transmitted. Individually configurable for blocking, permissive or direct tripping. Single purpose teleprotection in the 2 kHz APLC chalnnel: 3 independent commands (as above) and 1 prioritised command (for direct tripping).
Secure against	Noise (continuous or impulsive), speech and sweep tones, DTMF (CCITT 48430 or ITU-T Q.23) in-band signalling
Bandwidth requirement	Nil; command signal transmission in-band (alternate purpose with signal boosting)
Processing of received signal	Adaptive (to prevailing channel condition, always ensuring shortest transmission time)
Guard signal	Pilot signal or own guard signal in speech band

Number and type of inputs Method of tripping Voltage ranges	16 optocoupler per tele protection interface Contact and battery, or dry contact 24 to 250 V DC, selectable in 4 ranges.		
Number and type of outputs Tripping voltage Tripping current	16 solid state relays contacts per tele protection interface. 5 to 250 V DC ≤ 1 A carry / 2 A peak solid state 5 A carry / 20 A peak mechanical relay		
HMI configurable	Command and alarm assignment to I/O ports, Command pick-up times, hold times, duration monitoring State of command outputs during link alarm Alarm and unblocking level thresholds		
Test facilities	Manual or periodic loop test every 1,3,6,12,24 hours.		
Event recording	Time-stamped command events, command counters, stored in non-volatile memory. GPS Clock synchronizing input should be available		
Teleprotection performance	Blocking	Permissive tripping	Direct tripping
Overall time for PLC, VFT and transmission path	<20 ms	<20 ms	< 30 ms
Operating time lower than the specified maybe preferred provided they fulfil the requirements of security and reliability as mentioned: False Trip Probability (Noise burst of any amplitude) : 10^{-5} or better Fail to trip probability for S/N 6 dB in 3.1kHz Band (white Noise Measurement) : 10^{-2} or better			

19.6.0 TECHNICAL SPECIFICATION 48V PLCC BATTERY BANK

19.6.1. TYPE AND RATING

i) Stationary type, sealed, valve regulated lead acid battery tank suitable for operation on 48 Volts D.C. system to meet loads like emergency lightning, control and signaling circuits, relays, breaker operations, indicating circuits, etc. shall be required. The stationary battery shall comply with the provisions of IEC 896, Part 2 / ANSI T1.330.

ii) The Ampere-hour capacity of the battery bank at 27°C at 10 hours discharge rate shall be 200 AH.

iii) The nominal voltage of the battery bank shall be 48 Volts D.C.

iv) The number of cells in a complete battery bank set shall be 24 plus 2 spares.

19.6.2 PLATES

Positive plates shall be made of flat pasted type using lead-cadmium antimony alloy for durability, high corrosion resistant, maintenance free, long life both in cyclic as well as in ,float applications. Negative plates shall be heavy duty, durable flat plate using lead calcium alloy pasted box grid. Negative plates shall be designed to match the life of positive plates and combination of negative and positive plates shall ensure long life, durability and trouble-free operation of battery. PLC operated equipment should be deployed for preparation of paste to ensure consistency in paste quality. Conventional / manual type of paste preparation is not allowed.

19.6.3. CONTAINER AND LID

The containers and lids shall be made of a special grade polypropylene copolymer plastic material. They shall be sufficiently robust and not liable lo deformation under internal operating pressures and within the temperature range naturally encountered, leak proof, non-absorbent and resistant to the acid with low water vapour permeability.

19.6.4 VENT PLUGS

Each cell shall be equipped with one-way safety valve with opening pressure of 5±1 psi and closing pressure 4±1 psi. The vent plug shall be made with suitable grade of fire retardant plastic material. Each valve opening shall be covered with flame barrier capable in preventing the ingress of flame into the cell interior when the valve opens and hydrogen / oxygen gas mixture is released.

19.6.5. SEPARATORS

Separator shall be made of spun glass, micro porous matrix and shall be resistant to Sulphuric Acid. It shall be capable of keeping the entire electrolyte and shall be electrically insulated. Sufficient separator overlap and PVC shield protection to top and bottom edges of the plates is to be provided to prevent short circuit formation between the edges of adjacent plates.

19.6.6 CONNECTORS

The connectors shall be lead coated copper of suitable size to join the cells. The connectors shall be suitably designed and coated to withstand corrosion due to sulphuric acid. The coating should be adequate and tenacious. All the copper inter cell connectors shall be provided with heal shrinkable sleeves except at the connecting points.

19.6.7. ELECTROLYTE

The electrolyte shall be prepared from the battery grade Sulphuric Acid confirming to ISS: 266. The batteries shall be supplied in factory filled and charged condition.

19.6.8 WATER

Water required for preparation of electrolyte shall conform to IS: I069.

19.6.9. PLATE CONNECTION

Lugs of plates of like polarity shall be connected by lead burning to a horizontal strap having an upstanding terminal post adopted for connection to external circuit. Strap and post shall be caste with lead alloy. The positive and negative terminal posts shall be clearly marked for unmistakable identification.

19.6.10 BOLTS AND NUTS

Nuts and Bolts for connecting the cells shall be of superior grade passivated Stainless steel.

19.6.11 TERMINALS

Terminals shall be of integral lead terminal with solid copper core with M6 threading for fastening. The junction between terminal posts and cover and between the cover and container shall be hermetically sealed.

19.6.12. BATTERY RACKS

Batteries shall be installed on MS racks to be supplied by the Contractor to fit in the battery room. Racks/Trays shall be powder coated with anti-corrosive paint. Rack shall accommodate 55 cells plus 2 spares. Racks/Tray shall be suitably treated before painting for protection against fungus growth and other harmful effects due to tropical environment. The colour of the supporting racks shall conform to RAL 7032 shade.

19.6.13 CAPACITY REQUIREMENTS:

When the battery is discharged at 10 hour rate, it shall deliver 80% of Rated Capacity (corrected at 27°C) before any of the cells in the battery bank reaches 1.85 V/cell. The battery shall be capable of being recharged from the fully exhausted condition (1.75 V/cell) within 10hrs upto 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 that Rated capacity & not more that 120% of Rated capacity before any cell in the battery bank reaches 1.75 V/cell. The battery voltage shall not be less than the following values, when a fully charged battery is put to discharge at a rate of 1/10th of the Rated Capacity:

(a) After SIX hours of discharge: 1.92V/cell

(b) After EIGHT hours of discharge: 1.85V/cell

(c) After TEN hours of discharge: 1.75V/cell

Loss in capacity during storage at an average ambient temperature of 35°C 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%. However, the battery to be manufactured and to be delivered at site in such a way that load can be connected with the battery within 15 days from the date of installation. Date of initial charging is to be mentioned on the battery.

19.6.14 ASSOCIATED EQUIPMENTS & ACCESSORIES (For each set of battery) :

a) Best quality metallic stand/frame as per Clause 9.12.

b) Stand insulators +5% extra

c) Inter row connectors :Appropriate quantity

d) Inter tier connectors

e) Centre-zero (3-0-3) volts DC Voltmeter : 1 No

f) Torque wrench/ Spanners : 1 No

g) Connection hardwares, such as strips, bolts, nuts(with 5% extra)

h) Cable clamps with hardware

i) Cell numbering tags with fixing arrangement

j) Two sets of special tools and tackles for connecting terminals of the battery

k) Any other accessories not specified but required for satisfactory operation.

19.6.15 TYPE TEST OF BATTERY:

The Bidder/ Supplier shall supply type tested battery as per IS 15549:2004/ IEC 60896-21 & 22 over the range of at least one capacity per design. The Bidder/ Supplier shall submit necessary evidences enclosed along with tender documents.

Sl No	**DESCRIPTION**
1	Gas Emission
2	High Current Tolerance
3	Short Circuit Current & DC Internal resistance
4	Protection against Internal Ignition from External Spark source
5	Protection against Ground Short Propensity
6	Content & Durability of required marking
7	Material Identification
8	Valve Operation
9	Flammability Rating of Material
10	Intercell Connector Performance
11	Discharge Capacity
12	Charge Retention during Storage
13	Float Service with Daily Discharge 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 Stress Temperature of 60°C for brief duration exposure time with 3hrs discharge test
17	Abusive Over Discharge
18	Thermal Runaway Sensitivity

19	Low Temperature Sensitivity
20	Dimensional Sensitivity at Elevated Internal Pressure & Temperature
21	Stability against Mechanical abuse of units during installati

19.6.16 Routine Test:

(i) Physical Examination Test

(ii) Visual Inspection

(iii) Dimensions, Mass & Layout

(iv) Marking & Packing

19.6.17 ACCEPTANCE TEST OF BATTERY

(i) Polarity Marking

(ii) Verification of Dimensions

(iii) Open Circuit Voltage of each Cell & Total Open Circuit voltage of the battery bank

(iv) Test of AH Capacity

19.6.18 LIST OF FACTORY & SITE TESTS FOR BATTERY

Sr. No.	TEST	FACTORY TESTS	SITE TESTS
1	Physical Verification	YES	YES
2	Capacity Test on the cell at 1/10th of Rated Capacity, corrected at 27°C	YES	
3	8hrs Charge & 15mins Discharge Test at Full Rated Load	YES	

19.7.0 48V BATTERY CHARGER

19.7.1 General:

This section covers the general requirement of 48 V DC SMPS Based Power Plants, based on High Frequency Switch Mode Techniques using switching frequencies of 20KHz and above for use in AEGCL.

19.7.2 SMPS Based Power Plants is intended to be used in **Auto Dual Float Rectifier cum Boost Charger (FR-BC)** mode as a regulated DC Power Source.

19.7.3 Power System Configuration: The configuration of 48 V DC Power Plants with FR-FC & FRBC Modules shall be as under:

Sl No	Basic SMR Module	Configuration	Permissible Ultimate Capacity

1	25 A FR-FC	(n+1)	75 Amp
2	50 A FR-FC	(n+1)	150 Amp
3	25 A FR-BC	(n+2)	75 Amp
4	50 A FR-BC	(n+2)	150 Amp

The FR-FC or FR-BC modules shall be housed in (n+1) or (n+2) parallel configuration in a single rack where ‘n’ is the actual required number of FR-FC, FR-BC modules for meeting the particular load requirement.

AEGCL shall indicate the Type, Number and Configuration of SMR Modules, depending upon the load requirement.

19.7.3.1. The Battery Charger of 48V/25A (Ultimate capacity 150A) or 48/50A (Ultimate capacity 150A) N+1 configuration shall be of SMPS type and shall be chosen as per load demand of communication equipments of the substations. The system shall consist of DSA and Float Rectifier –cum-Charger (FR/FC) in a steel rack in a modular type. It should have menu driven microprocessor control technique for DSA as well as module for control, monitoring and alarm to achieve better reliability of the system.

19.7.3.2: The Battery Charger shall have Dual Source AC Input (AC Input 1 and AC Input 2) with individual MCCB and shall be provided with Auto Changeover arrangement.

19.7.3.3: The Battery Charger shall have an IP Rating of IP42 or better. The Charger shall be type tested for IP42 or better rating.

19.7.4 Rack Configuration :

Rack is composed of following units accommodated in sub racks

a) Dual Float Rectifier cum Boost Charger (FR-BC) Modules

b) Distribution-Switching-Control-Alarm Arrangement (DSCA)

c) The number and rating of FR-FC, FR-BC Modules shall be provided as per purchaser’s requirement. The Distribution-Switching-Control-Alarm Arrangement (DSCA) shall be provided for the Ultimate Expandable Capacity. All factory wirings for the rack shall be for the Ultimate Expandable Capacity so that only plugging-in of FR-FC or FR-BC module shall enhance the DC Power output.

19.7.5 Parts & Components

19.7.5.1 The Parts & Components including Fuses and Circuit Breakers for manufacturing of the SMPS Based Power Plants shall be of Industrial Grade. These Parts & Components shall be procured from reputed manufacturers to ensure prompt and continuous service and delivery of spare parts.

19.7.5.2 Power Transformers and Chokes shall use Class B or Higher Grade of insulation. The Transformers and Chokes shall be wound with copper wire provided with adequate insulation.

19.7.5.3 Component mounting and fixing methods shall be secured.

19.7.6. Wiring:

19.7.6.1 All insulated conductors except those within the confines of a printed circuit board assembly shall be of the rating enough to withstand the maximum current voltage during fault and overload.

19.7.6.2 All wiring shall be neatly secured in position and adequately supported. Where wires pass through any part of Metal Panel or Cover, the hole through which they pass shall be suitably bushed with rubber grommet.

19.7.7 Bus Bars:

19.7.7.1 Bus bars shall be of high conductivity electrolytic copper strips capable to with-stand 1.5 times the maximum load current. The Bus bar shall be capable to carry current density of 2 Amps/mm2 but shall not be less than 25mmx5mm in any case. The size of bus bars chosen for battery and load path shall be capable to take care of the current of maximum power plant capacity for which it is designed.

19.7.7.2 Bus-bar Riser height wherever applicable shall be 250mm for both load and battery.

19.7.7.3 Earthing: All non-current carrying metal parts shall be bonded together and earthed. An earth terminal suitable for taking minimum 4 mm dia wire and with suitable marking shall be provided.

19.7.8 The SMPS Based Power Plants shall be designed & manufactured for continuous operation at rated load in the ambient temperature range of 0ºC to 55ºC.

19.7.9 Insulation Resistance and Voltage Proof

19.7.9.1 The insulation resistance of a fully wired FR-FC and FR-BC Modules when tested with a 500V DC Megger shall be as given below:

a) AC input and Earth - Greater than 2 Mega Ohm

b) DC Output and Earth - Greater than 1 Mega Ohm

c) AC input and DC output - Greater than 5 Mega Ohm.

19.7.10 Lightning Protection :

The SMPS Based Power Plants shall have modular type Type I/Class B and Type II/Class C type surge protection in TT configuration of wiring. Both the Type I/Class B and Type II/Class C arrestors should be from the same manufacture and shall be mounted as per the specific installation recommendations of the manufacturer to achieve perfect coordination.

19.7.11 Radio Frequency Interference Suppression: The module shall be designed to minimize the level of electromagnetic interference (EMI), both conducted and radiated, detected in its vicinity and generated by Switch Mode Power Conversion Equipment operating within the rack.

19.7.12 Name plate :

A name plat etched/engraved/anodized or any other better arrangement ensuring better life expectancy shall be suitably fixed on each rack/module and contain followinginformation.

1. Specification Number

2. Type of Unit

3. Manufacturer’s name and identification

4. Model No.

5. Unit Serial No.

6. Input Voltage and phase

7. Output Voltage and current

8. Year of manufacture

9. Suitable for battery capacity

19.7.13 AC input supply: The Power Plant using FR-FC or FR-BC modules of 25 Amps shall operate from single phase AC input and FR-FC or FR-BC modules of 50A capacity may operate from single phase or 3 phase 4 wire AC input. The nominal input frequency is 50Hz which may vary from 48-52Hz. The input voltage range shall be as given below:

a) Single Phase (nominal 230V) :

For Power Plant to be used at stations having reasonable power supply regulation,incoming power supply range shall be from 165 V AC to 260 V AC.

b) Three Phase/4 Wire 400V+10%/ - 15% (Nominal 400V)

19.7.14 There shall be an automatic arrangement for shutting off the FR-FC or FR-BC Modules wherever the input voltage is beyond the specified operating limits with suitable alarm indication. It shall resume normal working automatically when the input is restored within the working limits. Hysteresis within specified working limits shall not cause shutting down of the FR-FC or FR-BC Modules. A tolerance of ±5V may be acceptable for protection & alarm operation. All the FR-FC or FR-BC Modules shall switch OFF simultaneously.

19.7.15 FR-FC or FR-BC Modules working from 3 phase/4 wire input shall work satisfactorily for unbalance of ±10% of nominal input. The module shall be isolated (if required for the protection of the unit) in the event of unbalance beyond 10% and shall restore when the input is within limits.

19.7.16 The SMPS battery charger shall be capable of continuous operation with float voltage 2.23 to 2.25 Volt per cell and 2.3 Volt per cell for charge voltage while supplying the constant DC load.

19.7.17 The SMPS battery charger shall have constant voltage characteristics throughout the range (from zero to full load) at floating value of the voltage so as to keep the VRLA batteries fully charged but without harmful overcharge.

19.7.18. The float cum boost charger works on 415 V AC, 50 Hz supply (or 230 V AC, 50 Hz supply). The battery charger should be capable of delivering the full rated load at the specified voltage at the output terminals. The set output voltage is maintained for AC input variation of + 10% and load variation from 0-100% of rated full load.

19.7.19 The charger voltage in float mode of operation is normally be set at 54 V DC and the same shall be adjustable between 48 and 54 V DC through variable potentiometer. When the charger is selected to boost mode, it should supply charging at the rated current maximum. This shall be adjusted from 20% to 100% of rated current through potentiometer.

19.7.20 All these circuits are housed in freestanding cabinet of folded sheet steel (thickness of sheet steel should not be less than 2.5mm) construction finished in stove enamel light gray colour conforming to shade of 631 of IS: 5. The cabinet is provided with front and back doors for easy accessibility. All meters, meter selector switches, control switches and LCD display (Microprocessor unit) etc are to be provided on the front panel. The AC input and DC output MCCB'S and control switches are provided on middle inside of the breaker panel. The cable terminations are provided on front side of the cubicles.

19.7.21 PARTICULARS FOR 48 VDC

Type FLOAT CUM BOOST CHARGER

Hot swappable rectifier modules 25A/48V, N+1 configuration.

TABLE-IV (a)

SL NO	DESCRIPTION	PARAMETERS
1	RATING	48 V (Capacity shall be as per Battery Sizing Calculation) Dual float cum boost charger (suitable for MF-VRLA battery).
	AC INPUTS	
2	VOLTAGE	415 V AC+ 10% (230V AC +10%)
3	PHASE	3 phase, 3 wire (single phase)
4	FREQUENCY	50 Hz+5% (50Hz+2Hz)
5	POWER FACTOR	(Better than 0.7 lagging)
	DC OUTPUT	
6	FLOAT VOLTAGE	48 V- 54 V DC
7	BOOST VOLTAGE	48 V-55.2 V DC
8	OUTPUT CURRENT	35A
9	VOLTAGE REGULATION	Better than + 1% of set value
10	RIPPLE	Less than 1% r m s
11	EFFICIENCY	(Better than 90%)
12	SYSTEM OUTPUT VOLTAGE	55.2V DC+1%(at load terminal)

METERS: The microprocessor-based controller should have metering facilities namely (a) Load Voltage (b) Load Current, (c) Battery Voltage (d) Battery Current (e) Battery Temperature, (f) Voltage and current of individual module.

TABLE-IV (b)

PROTECTION			
Over voltage trip at the output	:	Over voltage cutback	56.5+ 0.5 V DC
DC under voltage at battery input	:		42+ 0.5 V(1.75 V X 24)
Fuse at AC input	:	Fast acting semiconductor	Fast acting semiconductor

		fuse	fuse
Fuse at DC out put to load	:	MCCB	Fast acting semiconductor fuse
Reverse polarity at battery input	:	Protected	Protected
Out put current limiting	:		Battery charging current limit
AC input MCCB	:	Required	Required
Blocking diode	:	Required	Required
Charger over load	:	Required	Required
<u>INDICATION</u>			
AC input ON	:	Required	
DC output ON	:	Required	
Float ON	:	Required	
Boost ON	:	Required	

AC under voltage	:	Required
AC over voltage	:	Required
DC over load	:	Required
DC over voltage	:	Required
Short circuit	:	Required
Reverse polarity	:	Required
Mains fail		Required
Charger fuse fail		Required
Battery over voltage		Required

TABLE-IV (c)

<u>CONTROLS AND SWITCHES</u>

AC input MCCB	ON/OFF switch at input
DC output MCCB	Three-way switch to select auto / manual float / manual boost operation
Auto/manual float/boost mode selector switch	Two-way switch to read charger output current or battery charge / discharge current
Auto /manual voltage regulator selector switch	Single tern potentiometer for float voltage adjust
Float and boost voltage variable potentiometer	Single tern potentiometer for boost voltage adjust
Manual voltage adjust variable potentiometer	Single tern potentiometer for charger total current adjust
Battery current adjust potentiometer	Single tern potentiometer for battery current adjust
Heaters power supply switch	
Socket power supply switch	
ADDTIONAL FEATURES	
Soft start on DC side	Auto float / boost operation

19.8.0. TECHNICAL SPECIFICATION OF PAX SYSTEM

19.8.1. The offered exchange shall be the latest state of-art digital 32-bit microprocessor based suitable for direct connection to PLCC terminals, Optic Fibre, Digital Microwave, VSAT, etc, without the need for any four wire interconnection device. The design shall employ stored program technique and utilizes the principles of Time Division Multiplexing / PCM technology.

19.8.2 The offered EPAX directly interface with the Power Line Carrier Communication terminals with E & M signalling. The EPAX shall also support the CO trunk. The software of the EPAX should support both the E & M and CO trunks and should have the facility to be interconnected to P & T trunks for CO Access.

19.8.3 The EPAX should support single, two- or three-digit numbering scheme. The exchange should support a minimum of 16 out pulsing digits and a maximum of 20 out pulsing digits at time from a normal telephone. The exchange should be fully Non-blocking.

19.8.4 The duplication of both CPU and PSU is to be provided as in-built features in the offered exchange.

19.8.5 The EPAX should support a maximum configuration of 250 Ports. The EPAX shall have universal ports wherein any type of line card or trunk card of the EPAX can be inserted into any slots. Also, the number of trunks can be either E & M or CO or a combination of both. The offered exchange shall work purely as a PLCC switch or a combination of PLCC & CO or a network switch or a combination of PLCC, CO, Fibre and digital microwave.

19.8.6 The offered switch shall have an integrated E1 type card wherein a direct 2 MB stream can be connected to the switch.

19.8.7 The switch shall have ISDN compatibility for interfacing with PSTN and other public ISDN exchanges. A valid TEC certification for ISDN compatibility to be enclosed without the same the bid is liable for rejection.

19.8.8 The switch shall be equipped with voice guidance feature to navigate the subscriber in using the major features of the exchange. Data transmission through MODEM pooling shall be available in the exchange. The EPAX shall support exclusive Load Despatch Express type communication network with all to one and one to All type of trunk access. This feature shall be in addition to the normal All to All type. The exchange offered needs to be type tested for EMC specifications in line with IEC recommendations 495 for PLCC equipment. A valid certification for EMC compliance from any government laboratory within three years as on date of bid opening needs to be enclosed with the bid. The EPAX must have been EMI / EMC tested for the following as per IEC 495 to suit the stringent conditions in the Sub-station environment.

a. Impulse Voltage withstand test (IEC 255-4).

b. High Frequency disturbance susceptibility test (IEC 255-22-1).

c. Electrical Fast Transient Susceptibility Test (IEC 801-4).

d. Electrostatic discharge susceptibility test (IEC 801-2). Radiated susceptibility (IEC 801-3).

19.8.9. The Bidders shall offer suitable telephone equipment for automatic dialling which must work in full cordination with the already provided telephone equipment in the existing PLC system.

19.8.10 The bidder shall offer the latest state-of-art digital based Microprocessor EPAX suitable for direct connection to the PLCC terminals without the need of any four wire-interconnecting device (EFGS/EMFGS). The EPAX shall employ stored programme technique and utilize Time Division Multiplexing.

19.8.11. The EPAX shall be suitable for internal communication between the local subscribers as well as for selective communication over tie lines.

The special features of the offered EPAX shall be as follows:

i) EPAX is of latest microprocessor-based design, which employs Pulse Code Modulation/Time Division Multiplexing principle.

The following are the advantages over space division/reed relay switching:

a) Fully solid-state circuitry and hence high reliability in operation.

b) Fast response

c) Low operation and maintenance cost

d) High traffic handling capacity - Fully Non-blocking type

e) Compact size

f) Noise free operation

ii) Self checking diagnostics facility as a built-in feature of the EPAX. In view of this, the maintenance of the EPAX is extremely simple.

iii) The design of the software structure should be very flexible. Using any standard telephone instrument, the following programming shall be done at site:

- Modification of local subscriber number
- Modification of subscriber priority
- Modification of subscriber facilities like Access to Tie lines and Follow Me
- Modification of Tie line number
- Modification of Tie line groups
- Modification of Exchange number
- Allocation of Alternate route
- Transit call barring

The above programming facility at site should not require any additional test equipment.

iv) Built-in main distribution frame with Protective Devices such as surge arresters and fuses for all limbs of subscriber lines and tie lines to protect the sophisticated electronic circuitry of the exchange from damage due to external surges/spikes.

v) The EPAX is suitable for easy expansion if required at a later date.

As per your requirement, supply of EPAXs equipped with 16,32,64 subscriber lines and 8,16,32 tie lines (PLCC directions). The ultimate capacity of the EPAX shall be 250 ports for flexible usage of either the subscriber lines or trunk lines.

19.8.13. The line interface circuit module shall serve as an interface between the subscriber line and the exchange whereas the trunk interface circuit module shall serve as an interface between the tie line and the exchange. However, the EPAX shall be possible to expand either the number of subscriber lines or tie lines if required, at a later date, in view of the modular construction adopted. The EPAX shall have a 32-bit microprocessor and programmable at site. The software shall support both E&M signalling and CO trunks. The EPAX shall be provided with universal ports wherein the Subscriber line card and CO trunk card can be inserted into any slots. . If the ultimate capacity of the trunks has been used and on a later date the board intends to increase the trunk capacity the same can be done by decreasing the subscriber lines and thereby increasing the trunks. Vice versa for subscriber lines if the ultimate capacity is reached by reducing the trunks the subscriber lines can be increased.

19.8.14 The duplication of both the CPU and PSU is to be provided as an in-built feature in the offered EPAX. The EPAX shall support the digital telephone with display on a single pair of cable. The offered EPAX shall be provided with a voice guidance card, which helps the subscriber in using, the all the features of the exchange viz. call back etc. The EPAX shall be fully automatic and should function without the help of an operator. The details of site programming facility shall be provided in detail.

19.8.15. The EPAX shall have the following facilities:

a) Follow me

b) Priority interrupt/Conference

c) Automatic alternate route selection

d) Ring when free

e) Line Lock out

f) Either party release

g) Real time clock

h) Audible and visual alarm on all fault conditions.

19.8.16. The EPAX shall be self-contained and provide its own ringing current and tones.

19.8.17. Visual display with LED's shall be available on each line and trunk card to display call status. Visual and audible alarms shall be provided on all fault conditions based on the self-diagnostic routines.

19.8.18. The EPAX is to be housed in dust proof steel cabinet.

19.8.19. The EPAX works on 48V DC +15% -10% supply. The loop resistance for subscriber lines is 1000 ohm maximum and for Tie lines 1500 ohm maximum.

19.8.20. The offered EPAX shall support the system software to work as an exclusive PLCC exchange or a combination of PLCC and CO trunks or as a network exchange on E&M. It is very important to note that these three combinations shall be available on the system software so that the purchaser can switch to the exact application at the time of commissioning. The offered EPAX shall work in conjunction with the existing EPAXs of other makes in the grid.

19.8.21. The offered EPAX shall have ISDN compatibility for the CO trunks. The system software shall be posted on flash memory as per the latest International standards for fast and reliable operations. The EPAX shall also support a minimum dialling of 16 digits at a time and a maximum of 20 digits. The EPAX shall have compatibility with E1 trunks for expansion in later stage. It should have the software in-built for through connectivity from E1 trunk to PLCC trunks.

19.8.22. The EPAX should be provided with universal ports for peripheral cards so that any combination of subscribers and trunks can be selected by the user by inserting suitable interface cards.

19.8.23. The EPAX must have been EMI/ EMC tested for the following as per IEC 495 to suit the stringent conditions in the Sub-station environment.

1.Impulse Voltage withstand test. (IEC 255-4)

2. High Frequency disturbance susceptibility test (IEC 255-22-1)

3.Electrical Fast Transient Susceptibility Test (IEC 801-4)

4.Electrostatic discharge susceptibility test (IEC 801-2)

5.Radiated susceptibility. (IEC 801-3).

19.9.0 TECHNICAL SPECIFICATION OF HIGH FREQUENCY COAXIAL CABLE

19.9.1 The high frequency coaxial cable shall be required to connect the line matching unit / line matching distribution unit installed in the switchyard of the substation to the carrier equipment installed in the carrier rooms.

19.9.2. The high frequency cable to be offered by the bidders shall be suitable for being laid directly to the ground or in trench or ducts.

19.9.3. The cable shall be PVC sheathed and steel armoured. The capacitance of the cable shall be low so as to minimise attenuation of the signal within carrier frequency range. The impedance of the cable shall be so as to match the output impedance of the PLC terminals and secondary impedance of the coupling units. The cable shall be installed to withstand a test voltage of 4 KV.

19.9.4 Bidders shall specify attenuation per Km. of high frequency coaxial cable at various frequencies in the range of 80 to 450 KHz.

19.9.5. High frequency cable shall be supplied on drums containing lengths of minimum 500 metres.

TABLE-V

Sl No	Description	Particulars
1	COAXIAL CABLE	1/1.22mm HF Coaxial Cable having annealed plain tinned copper wire centre conductor, Semi-Air spaced dielectric of composite helical thread of polythene in a polythene tube and annealed plain tinned copper wire braided, Melinex tapped, extruded, special PVC sheathed, black steel wire Braid armoured and characteristic impedance of 75 ohms.
2	Centre Conductor	Tinned copper wire of 1.22 mm dia.
3	Cable Core and Air	Centre Conductor wrapped with Spaced Centre Conductor wrapped with Spaced Radial thickness:1.00 mm. Diameter over Pe tube: 5.20 mm.
4	Outer conductor	Braid of tinned copper (Electrolytic grade/wire of 0.20mm dia with 90% coverage.
5	Barrier	PVC/MYLAR Tape.
6	Inner Jacket	Special cable grade PVC Radial thickness 0.70 mm.
7	Bedding	PVC Tape.
8	Armouring	0.4mm GI wire, 70% coverage.
9	Overall jacket	PVC.
10	Electrical data:	
11	Max Conductor resistance @ 20%	15.7 Ohms/KM
12	Dielectric strength(Core to shield)	4KV RMS for 1 minute

13	Nominal impedance	75 ohm
14	Nominal capacitance at 1Khz	53 pf/meter
15	Mx. Attenuator frequency (KHZ)	(KHZ) db/km 10 0.80 60 1.40 300 3.30 500 4.70
16	Min.Bending radius	15 Cm

CHAPTER 20: TECHNICAL SPECIFICATION FOR XLPE CABLE WITH TERMINATION

TECHNICAL SPECIFICATION OF 33KV, 66KV, 132KV, 220KV & 400KV XLPE CABLE AND TERMINATION

20.1 SCOPE

The specification covers Design, Engineering, Construction, Supply & Delivery, Erection, Laying, Testing & Commissioning including Transportation & Insurance, Storage of XLPE Cable of different ratings and their associated works.

20.2 STANDARD & CODES

The works covered by the specification shall be designed, engineered, manufactured, tested and commissioned in accordance with the Standards as specified in the table below.

Other internationally accepted standards which ensure equivalent or better performance than that specified in the standards referred shall also be accepted. Copies of such standards shall be submitted by the bidder along with the bid.

IS 7098 : Part 3 : 1993	Cross-linked polyethylene insulated thermoplastic sheathed cables: For working voltage from 66KV up to and including 220KV.
IS 8130 : 1984	Conductors for insulated electric cables and flexible cords
IS 5831 : 1984	PVC insulation and sheath of electric cables.
IS 1255 : 1983	Code of practice for installation and maintenance of power cables upto and including 33KV rating.
IS 3975 : 1999	Mild steel wires, formed wires and tapes for armouring of cables.
IS 5831 : 1984	PVC insulation and sheath of electric cables.
IS 6380 : 1984	Elastomeric insulation and sheath of electric cables.
IS 8130 : 1984	Conductors for insulated electric cables and flexible cords.
IS10418 : 1982	Drums for electric cables
IS 5 : 1994	Colours for ready mixed paints and enamels.
IS 617 : 1994	Aluminum and aluminium alloy ingots and castings for general engineering purposes (Superseded IS 20: 1977)
IS 3043 : 1987	Code of practice for earthing.
IS 5578 : 1984	Guide for marking of insulated conductors.
IS 11353 : 1985	Guide for Uniform System of Marking and Identification of Conductors and Apparatus Terminals.
IS 5216 : Part I : 1982	Recommendations on Safety Procedures and Practices in Electrical Work.
IS 2071 : 1993	High voltage test techniques.
IEC-60540	Power cables with extruded insulation and their accessories and cords
EC 60060 : 1989	High Voltage Test Techniques
IEC-60502	Extruded solid dielectric insulated power cables for rated voltages from 1KV up to 30KV
IEC-60754 : 1991	Tests on gases evolved during combustion of electric cables
IEC-60183 : 1990	Guide to the Selection of High Voltage Cables.
IEC-60230 : 1996	Impulse tests on cables and their accessories.
IEC-60840 / IEC-62067	Testing
IEC-60287 : 1995	Calculation of the continuous current rating of cables (100%load factor).
IEC-60304 : 1982	Standard colours for insulation for low-frequency cable and wires
IEC-60331 : 1970	Fire resisting characteristics of Electric cables.

IEC-60332 : 1992	Tests on electric cables under fire conditions.
BS-5468	Cross-linked polyethylene insulation of electric cables
IEC-60228 : 1978	Conductors of insulated cables
IEC-60332 : 1993	Test on electric cables under fire conditions
IEC-60066	Environmental Test
IEC-60117	Graphical Symbols
IEC-60270 : 2000	Partial Discharge Measurements
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
ASTMD-2863	Measuring the minimum oxygen concentration to support candle like combustion of plastics (oxygen index)

20.3 COMPLIANCE TO SPECIFICATION & DEVIATION:

Normally the offer should be as per Technical Specification without any deviation. But any deviation felt necessary to improve performance, efficiency and utility of equipment must be mentioned in the Deviation Schedule with reasons duly supported by documentary evidence. Such deviations suggested may or may not be accepted by the purchaser.

As a mark of technical conformance, all sheets of the specification shall be furnished by each bidder with the signature and company seal affixed thereon. In case of any deviations, the same shall be carried out in the deviation schedule only. Deviations not mentioned in Deviation schedule will not be considered.

The bidder shall also submit the GTP as per Annexure-1 duly signed with date & company seal for acceptance of the Technical Bid unless which the bid may be considered as non-responsive.

20.4 CONSTRUCTION

1. **For 66KV and above**: The cable shall be of applicable EHV grade as per requirement according to price schedule, single core, armored, stranded compacted circular Copper conductor in case of cross section less than or equals to 800 sq.mm or segmental compacted circular (Miliken) Copper conductor in case of cross section over 800 sq.mm, core screening by a layer of semiconducting tape followed by a layer of semiconducting compound, crosslinked polyethylene (XLPE) tree- retardant/ super clean dry cured insulation, insulation screening with semiconducting compound extruded directly over the insulation, longitudinal sealing by a layer of non woven tape with water swellable absorbent over insulation screen, followed by radial sealing of corrugated & seamless aluminum& overall HDPE sheathed (conforming to IEC 60840/ IS 7098 Part III)& graphite coated and conforming to the technical particulars of specification.
   For 33KV : Untinned annealed copper conductor of class 2 as per IS 8130/1984 and any latest amendments to it. The shape of conductor shall be compacted, stranded, and circular/ sector shaped, shielded with conductor screen of black extruded semi-conducting compound , XLPE insulation, shielded with insulation screen of black extruded semi- conducting compound, black semi-conducting tape and metallic screen of copper tape, Inner sheath extruded PVC type ST2, single layer of strip/ round steel, round hard drawn aluminium wire armoured and black extruded FR-PVC (TypeST-2) overall sheathed, conforming generally to IS:7098 (PartII

20.5 COMPOSITIONS OF CABLES

20.5.1 CONDUCTOR

For the cable sizes having cross section over 800 sq.mm, the segmental compacted circular conductor having minimum four (4) segments should be constructed for the supply under the scope of bid. When the conductor's cross-section is less than 400 sq.mm, the compacted circular is applied generally.

20.5.2 CONDUCTOR SCREEN

The conductor screen shall consist of extruded semi-conducting XLPE. Semi-conducting separator tapes may be applied between conductor and the extruded semi-conductor XLPE.

20.5.3 INSULATION

The insulation material shall be extruded cross-linked polyethylene for 33kV and tree-retardant/ super clean XLPE for 66kV and above.. In order to ensure that the screen and insulation are intimately bonded together and free from all possibilities of voids between layers, the conductor screen, the insulation and the insulation screen should be extruded simultaneously in one process in single cross-head. The extrusion process should be carried out under strictly controlled atmospheric conditions.

The thickness of the insulation layer should be maintained as the maximum value figured out from the design of the impulse voltage and A.C. voltage. The cross-linking process by N2 gas should be preferred instead of conventional cross-linking process by saturated steam.

20.5.4 INSULATION SCREEN

The insulation screen shall consist of extruded semi-conducting XLPE. Suitable bedding tapes shall be applied over the extruded semi-conducting XLPE.

20.5.5 MOISTURE BARRIER

The longitudinal water barrier shall be applied over insulation screen by a layer of non woven synthetic tape with suitable water swellable absorbent.

20.5.6 METALLIC SCREEN:

The metallic screen shall be of copper wire or corrugated aluminium as per IS. The metallic screen shall be designed to meet the requirement of the system short circuit rating of 31.5KA for 3 sec (for 33KV and 66KV), 40KA for 3Sec (for 132KV) and 50KA for 3 sec (for 220KV). Copper wire screening may be used if required to meet the above ratings.

ARMOURING (FOR 33KV CABLE)

i. The armoring shall be of non-magnetic material.
ii. Armoring shall be applied over the insulation or protective barrier or non-metallic part of insulation screening, in case of single core cables or inner sheath in case of screened and armoured single core cables.

c) The armour wires/strips shall be applied as closely as practicable the direction of lay of the armour shall be left hand. For double wires/strips armoured cables, this requirement shall apply to the inner layer of wires/strips. The outer layer shall, except in special cases, be applied in the reverse direction to the inner layer, and there shall be a separator of suitable non-hygroscopic material; such as plastic tape, bituminized cotton tape, bituminized hessian tape, rubber tape, proofed tape between the inner and outer layers of armour wires strips.

d) A binder tape may be applied on the armour.

e) The joints in armour wires of strips shall be made by brazing or welding and the surface irregularities shall be removed. A joint in any wire/strip shall be at least 300 mm from the nearest joint in any other armour wire/strip in the completed cable, Number of joint in a single wire to be limited.

20.5.7 OUTER SHEATH

The outer sheath shall consist of Extruded black HDPE (TypeST7) grade. The outer sheath shall be designed for protection against termite and rodent attack and shall be coated with graphite.

20.6 RATING

A complete set of calculation made in arriving at the current rating shall be furnished for laying condition and cable sheath bonding system adopted. Short circuit temperature shall be limited to 250 degree C.

20.7 CABLE DRUMS

Cables shall be supplied in wooden or steel drums of heavy construction of suitable size and packed conforming to IS 10418 or applicable internationally accepted standards. Wooden drum shall be properly seasoned sound and free from defects. Wood preservative shall be applied to the entire drum. A layer of water proof paper shall be applied to the surface of the drums and over the outer most cable layer.

Each drum shall carry the manufacturer's name, the purchaser's name, address and contract number and type, size and length of the cable, net and gross weight stenciled on both sides of drum. A tag containing the same information shall be attached to the leading end of the cable. A narrow and suitable accompanying wording shall be marked on one end of the reel indicating the direction in which it should be rolled.

Packing shall be sturdy and adequate to protect the cables, from any injury due to mishandling or other conditions encountered during transportation, handling and storage. Both cable ends shall be sealed with hermetically sealed by means of water blocking compound followed by heat shrinkable caps totally coated inside with mastic so as to prevent to cable for moisture penetration during transit, storage and laying.

The bidder shall consider supply of cable on returnable drums basis. Contractor shall take back all the cable drums from site after successful laying, testing and commissioning of cables. If any length of cable remains unused, the same shall be adjusted by the employer.

Embossing of outer sheet: the following details on the other sheet of cable at a regular interval of 1(one) meter.

(a) **Name of Customer i.e. AEGCL**
(b) **Conductor size, type of insulation and voltage grade.**
(c) **Manufacturer's name.**
(d) **Year of manufacturing**

20.8 TESTS

All routine and acceptance tests shall be conducted as per IEC60840/IEC62067. All type tests conducted during last five years from the date of NIT as per IEC 60840:1999/ IEC 62067:2001 including its amendments on the XLPE insulated HT cable should be submitted. The diameter of test cylinder during bending test shall be as per IS:7098 (Part3) or the diameter of drum barrel to be used for dispatch of cables which ever is lower. For accessories type test reports should be submitted as per Clause 11.3.2 IEC 60840:1999/ Clause12.4.2 IEC62067:2001 & including amendments.

Following additional type tests shall be carried out on outer sheath of XLPE insulated HT cable.

a. Oxygen index and temperature index test as per ASTMD-2863.
b. Chemical composition test for verifying lead sheath composition.

All tests as prescribed in IEC-60840 shall be performed after installation of cable.

TESTS AFTER INSTALLATION

All tests as prescribed in IEC-60840:1999/IEC 62067:2001 shall be performed after installation of cable.

20.9 TRENCHING

The cable trench work involves earth excavation for cable trench, back filling and removal of excess earth from site. The work site shall be left as clean as possible.

The trench shall be excavated using manual/ mechanical modes as per field conditions.

Where paved foot paths are encountered, the pavements labs shall be properly stored and reinstated. Identification markers of other services shall be properly stored and restored.

The sides of the excavated trenches shall wherever required be well shored up.

Suitable barriers should be erected between the cable trench and pedestrian/motor way to prevent accidents. The barriers shall be painted with yellow and black or red and white coloured cross stripes. Warning and caution boards should be consciously displayed. Red lights as warning signal should be placed along the trench during the nights.

The excavated material shall be properly stored to avoid obstruction to public and traffic movement.

The bottom of the excavated trench should be levelled flat and from any object which would damage the cable. Any gradient encountered shall be gradual.

20.10 LAYING OUT

The excavated cable trench shall be drained of all water and the bed surface shall be smooth, uniform and fairly hard before laying out the cable. The cable shall be rolled in the trench on cable rollers, spaced out of uniform intervals. The laying out process must be smooth and steady without subjecting the cable to abnormal tension. The cable on being laid out shall be smoothly and evenly transferred to the ground after providing the cushion. The cables shall never be dropped. All snake bends shall be straightened. Suitable size cable stocking pulling eye shall be used for pulling the cable. While pulling the cable by winches or machines, the tension loading shall be by tension indicator and shall not exceed the permissible value for the approved cable pulling tension calculation.

The cable end seal shall be checked after laying and if found damaged shall immediately be resealed. Sufficient number of heat shrinkable cable end sealing caps shall be stocked at site stores for testing and jointing work. The integrity of the outer sheath shall be checked after the cable is laid in position.

20.11 LAYING OF CABLES

The installation, testing and commissioning work for laying of cable in the entire route within the substation, through the outside cable laying corridor as per designated approved route shall mainly consist of:

a) Route survey for the entire route length under the scope of work. This is also to finalize drum wise cable length with their tolerances.
b) Clearances from relevant authorities for lying of cables.
c) Formation of buried cable trenches for cables as per specification including supply and installation of warning tape, protective tiles / brick layer of minimum class designation 50 (50kg./sq.cm.) cable protection covers for entire route, construction of jointing bays, back filling of trenches and restoration as per specification.
d) Road crossings shall be through HDPE pipe embedded in concrete duct for each cable and restoration as per specification. Rail and canal crossings shall be through direct drilling with steel drum.
e) Cable markers as per statutory requirements shall be provided all along the route at a maximum distance of 500 meters and other important locations. Also the location of underground cable shall be clearly indicated on the marker.
f) Supply and installation of straight through joints for complete route.
g) Design, supply and installation of suitable hangers and other necessary structures for running the cable at over head road bridge.
h) Supply and installation of all critical installation materials like trefoil clamps, neoprene cushions, support brackets etc. as required for complete route to avoid damages of the cable. Neoprene cushion shall be provided at road and rail bridge crossings to avoid damage of cable due to vibrations during movement of trains and vehicles.
i) Termination of cables, bonding of screen/sheath to the earth station through disconnecting type link boxes and SVL (sheath voltage limiter) at cable conductor junction-point etc. Bidder shall adopt cable sheath bonding for route under scope as per detailed Engineering calculation in line with IEEE 575. Earthing stations/ Earthing pits, earthing materials and earthing conductors wherever applicable for complete route including outdoor equipment, structure, cable terminating structure and earth link box at the locations mentioned above shall be in contractors' scope.
j) Design, fabrication, supply and erection of galvanized steel structures (including its civil foundation) for cable end terminations (with all necessary accessories) for cable sat cable–conductor junction point. At cable-conductor junction point terminal connectors offered by bidder shall be suitable to terminate with ACSR conductors.

k) For termination at GIS substation end the cable should be laid up to GIS module inside the GIS building. Necessary design construction of cable duct/ trench/ cellar etc. in the GIS Sub-Station including all supply is within the scope of this contract.
l) Design, supply and installation of LA sat cable–conductor junction point for both the circuits including its mounting structure and Las & Isolator sat Sub-Station.
m) Termination, bonding, earthing etc. at GIS sub-station end is not within the scope of this work.
n) All EHV cable routes shall be provided with one linear heat sensing cable to detect any fire and provide alarm.

20.12 LAYING OVER PRE-CONSTRUCTED TRENCH

For laying of the cable on a pre-constructed trench below the road in any planned township area, Bridge, switchyards etc., cable shall have to be accommodated in the space allotted in the trench for laying the cables. Sufficient clamping arrangement shall be done for fixing the cable properly. Cables may be placed in trefoil arrangements as per allotted width of the trench. The clearances between the cable trays shall be minimum 330mm for cables up to 132kV and 400mm for cables of 220kV and 400kV. For 66kV cables, maximum two bends are allowed in 20 mtr span and for 132kV, 220kV and 400kV cables, not more than one bend shall be provided in 20 mtr span. Any damages occurred in the trench during lay of the cable shall have to be repaired properly.

Wherever there is crossing with any utility line, the utility line will cross the cable route/ jointing bays at minimum separation distance of 500mm below cable route/ jointing bays.

20.13 CLAMPS

Clamps shall be pressure die cast aluminium (LM-6) or Nylon-6 or fiber glass and shall include neoprene rubber lining wherever the cable touches the clamps and below the clamp base and necessary fixing non magnetic nuts, bolts, washer etc. The thickness of neoprene rubber shall not be less than 10 mm inside around the inner surface of the trefoil clamp and minimum 20 mm thick below the base of trefoil clamp. The neoprene shall be tested as per ISIII49-1984. Clamps shall be provided at every one meter of cable runs. The contractor shall submit drawings of trefoil clamps and arrangements for Employer approval.

Self supported Aluminium Spring load clamp shall be provided for Cable termination structure at every 1 metre of cable run. The contractor shall submit the drawings of spring load clamp for employer's approval.

20.14 CABLE HANDLING

The inspection of cable on receipt, handling of cables, laying out, flaking, cushioning with sand or sieved compacted soil, back-filling, reinstatement of road surface, providing and fixing joint markers, route indicators, precautions of joint holes, sump holes and all necessary precautions that are required shall be carefully planned and in general conform to IS1255-1983 or its equivalent.

CABLE JOINTING BAYS

Cable jointing bays shall be provided for single core EHV cables in a staggered manner along the cable route with adequate space for bonding of sheaths and link boxes as well as for testing. The jointing bays shall have adequate number of cable ducts entry and exits including spare ducts with fire seals. The jointing bays shall have chequered covers of minimum 6mm thickness

DAMAGE TO PROPERTY

The contractor shall take all precautions while excavation of trench, trial pits etc., to protect the public and private properties and to avoid accidental damage. Any damages caused shall be immediately repaired and brought to the notice of the concerned and to the Employer.

- The contractor shall bear all responsibilities and liabilities and shall bear all costs of the damages so caused by him or by his workman or agents.
- At places where the cables cross private roads, gates of residential houses or buildings, the cables shall be laid in HDPE pipes of adequate strength using HDD technology.

20.15 CABLE ROUTE MARKERS / CABLE JOINT MARKERS

Permanent means of indicating the position of joints and cable route shall be fabricated supplied and erected as per drawings approved by AEGCL.

Cable markers as per statutory requirements shall be provided all along the route at a maximum distance of 30 meters and at all turning points and other important locations.

Markers provided shall be as per the field requirement, if the route passes through open fields, markers should be conspicuously visible above ground surface.

The marker should incorporate the relevant information, The name of the owner, voltage, circuit and distance of cable from the marker.

20.16 DEPTH OF LAYING OF CABLES

Depth of lay shall be normally at 1.5 m. below ground but variation of depth of lay to1 meter may be considered at the time of detailed engineering on the characteristics of the laying zone.

20.17 SAND BEDDING

The cable shall be completely surrounded by well-compacted cables and to such a thickness and of such size that the cable is protected against damage. The thickness of the cable sand should normally be a minimum of 10 cm in all directions from the cable surface.

20.18 THERMAL BACK FILL

Based on the evaluation of soil thermal resistivity along the cable route and after approval from the Employer the contractor shall design, specify, supply, lay and monitor the installation of thermal back fill surrounding the cables.

20.19 IMMEDIATE ENVELOPE TO CABLE

The option on the use of the material that immediately envelopes the cable viz., thermal back fill or sand or sieved native soil rests with the Employer. The contractor shall seek prior approval on the use of the envelop material from the Employer before execution of the works.

20.20 BACKFILLING

Normally back filling shall consist of the material earlier excavated. However, bigger stores or pieces of rock should be removed.

20.21 WARNING TAPE

A pre-warning, Red colour plastic/ PVC tape, 250 mm wide100 microns thick, shall be laid at approx. 0.4m above the cable specified depth, throughout the cable route. The tape shall carry the legend printed in black continuously as under

CAUTION: AEGCL ….. KV CABLES.

20.22 PREVENTION OF DAMAGE DUE TO SHARP EDGES

After the cables have been laid in the trench and until the cables are covered with protective covering, no sharp metal tool shall be used in the trench or placed in such a position that may fall into the trench.

Straight and curved rollers used shall have no sharp projecting parts liable to damage the cable.

While pulling through pipes and ducts, the cable shall be protected to avoid damage due to sharp edges. The cables shall never be bent, beyond the specified bending radius.

20.23 ROAD, RAIL & CANAL CROSSINGS

The road cutting, whether cement concrete asphalt or macadam road surface, rail crossing and canal crossing shall be taken after obtaining approval from the concerned authorities i.e. Railway authorities, irrigation deptt, civic authorities traffic police, telephone authorities etc. and work should be planned to be completed in the shortest possible time. Where necessary, the work shall be planned during night or light traffic periods. HDPE pipes shall be used for cable. HDPE pipes diameter should not be less than1.5 times the cable diameter.

20.24 TRENCHLESS DIGGING

It is envisaged that trenchless digging shall be used for crossing National highways, Rail line and canal and this shall be in the scope of bidder. Trenchless digging shall also be used where the concerned authorities do not permit open cut method and it is essentially required to carry out for installation of underground cables. The trenchless digging methods shall generally conform to ITU-T 1.38. The various methods of trenchless digging such as hand/ manual auguring (upto15m.) impact moulding (from 16m to about 40-50m.).HDD (above40-50m) shall be adopted based on the soil/ site conditions and the requirement and exact method for trenchless digging shall be finalized during detail engineering as per actual site/ soil condition. The equipment used for HDD shall be capable of drilling at least 100m at one go. The contractor shall propose the exact methods and procedures for implementation of trenchless digging at various crossings taking into consideration the following guidelines, for approval by the Employer.

1. Guided boring/drilling technology is to be used.
2. Radio or any detection system should be used for avoiding damage to existing underground utilities.
3. The depth of boring should be such as to clear any underground utilities/obstacles. However in no case the depth of boring shall be less than 1.65m from the road surface.
4. In horizontal and vertical boring, the system should be capable of going up to 10 meter below ground.
5. The span of HDD will be decided in charge as per site requirements.
6. Excavation and back filling of trial pits and verification of soil condition.
7. Excavation of entry and Exit pits.
8. Erection of drill machined. Drilling of pilot hole.
9. Placement and driving hand augur.
10. Placement and carrying out impact moling.
11. Reaming and widening of bore holes in steps (if required).
12. Pulling of product pipe.

20.25 FOOTPATH CUTTING

The slabs, curb stones on the roads shall be removed and reinstated without damage. For laying of cables, the specified approved corridor shall be followed below footpath.

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20.28 TOOLS AND PLANTS

The successful bidder shall have all necessary tools, plant and equipment to carry out the survey and cable installation work.

The bidders are instructed to give all the details of equipment at their disposal to carryout the work successfully and speedily.

20.29 BENDING RADIUS:

The minimum bending radius of XLPE insulated cables are as follows :
Cable Bending radius Single Core 25 X D
“D” means the overall diameter of the completed cable.
This bending radius is applicable for direct buried cable route and cable trench.

20.30 CABLE END TERMINATIONS & JOINTING

i) The cable jointing accessories shall include the end terminating kits, straight through joints and also any special tools and tackles required for making these joints.

ii) The straight through joints shall be either Pre-molded Heat Shink type complete with all accessories. The joint shall preferably be built up as per the construction of the main cable and shall have electrical and mechanical withstand capabilities same as or better than the main cable. The joints shall be suitable for tropical climatic conditions. All straight through joints and cable terminations shall have field proven experience of minimum five (5) years without any latent design defects.

iii) The outdoor end termination up to 245 KV XLPE Cable shall be Anti-fog, Pre-molded type Silicon Rubber stress cone. Torque controlled mechanical shear head bolted connector with polymeric composite housing (resin cast body with silicon shed housing), dry/fluid filled (silicon oil) type self-supporting with Plug-in / Plug-out facilities. The termination base plate and the cable's metallic sheath shall be electrically insulated from the self supporting structure by means of stand-off epoxy insulators designed to withstand both mechanical and electrical stresses in services. The Polymeric insulator in grey colour shall be used. In addition upon, arcing horn and shield ring shall have to be supplied as required for 245 & 420 KV XLPE cables. 10%etra silicon oil shall be supplied with termination if fluid filled is supplied.

iv) The outdoor end termination for 400kV shall be based on the Silicon / EPR-based stress relief cone with the epoxy housing and the oil-impregnated cylindrical capacitor cone (so called condenser cone type) to secure the uniform longitudinal voltage distribution all along the termination. Pre-molded type Silicon Rubber sleeve outdoor end termination for 400kV may be offered by the manufacturer if the same is available.

v) The outdoor terminals should be suitable for heavily polluted atmospheric conditions with total creepage distance of 31 mm/ kV and protected creepage distance of not more than 50% of the total creepage distance. The cable end terminals for terminating the cables shall be fully compatible with the cables to be supplied.

vi) The Indoor Termination at GIS SF6 Housing shall be based on the Silicon Rubber based stress relief cone and the epoxy resin housing. There shall be mechanical devices to maintain the interface pressure. Stress relief cone and mechanical devices shall be designed to fit with controlled interference over the cable insulation and shall follow the cable's diameter variations still guaranteeing under any service condition a sufficient positive pressure to control the electric field concentration. There shall be epoxy insulating plate to isolate between cable sheath and GIS chamber. The SVLs (Sheath Voltage Limiter) shall be installed to protect epoxy insulating plate from switching impulse. Plug-in type leading conductors shall be supplied though at the time of detailed engineering confirmation shall be given for selection of plug-in type. Design and scope of delivery shall be fully complying with IEC-60859, IEC-62271-209 and possibly adjusted to various needs of project. The main insulation components shall be fully examined and tested in the factory.

vii) For jointing and terminations, one qualified Engineer and required trained EHV jointers with supporting staff should be deputed. The engineer and EHV jointers shall posses valid certificate from the manufacturer of the Accessories, for erection.

viii) The detailed description on jointing procedure shall be furnished during detailed engineering.

ix) The details of the performance of end terminations / straight through joints as offered with the period in service in reputed Indian Utility should be furnished for 145 KV & 245 KV and reputed International/ Indian utility for 420 KV Cable accessories for evaluation of the techno-commercial offer.

x) The accessories shall be Type Tested as per relevant IEC 60840 & Type test report shall have to be furnished for technical evaluation.

20.31 WORKING PROCEDURE FOR TERMINATION

(i) At cable terminating end sufficient length of spare cable shall be left in the ground and at cable tray also at GIS, for future needs.

(ii) The rise of the cable immediately from the ground shall be enclosed in PVC/ PE pipe of suitable diameter to protect against direct exposure to the sun.

(iii) The cable shall be properly fastened using non-metallic clamps.

(iv) Appropriate labels shall be fixed identifying the phase circuit, voltage and date of commissioning etc., on the cable supporting structure.

(v) The sealing end shall be mounted on pedestal insulators to isolate them from their supporting steel work.

(vi) Protection from contact with the exposed metal work at the termination shall be provided by resin bonded glass fiber shroud.

(vii) Providing earth stations with all required materials, like leads, connectors etc. Earth pits shall conform to IS-3043:1987 (Code of practice for earthing).

20.32 WORKING PROCEDURE FOR JOINTING

(i) The cable jointing personnel and his crew shall have good experience and with HT license in the type of jointing and terminations that are used. The jointing works shall commence as soon as two or three lengths of cable have been laid. All care should be taken to protect the factory-plumbed caps/ seals on the cable ends and the cable end shall be sealed whenever the end is exposed for tests.

(ii) Jointing of cables in carriage ways, driveways under costly paving, under concrete or asphalt surfaces and in proximity to telephone cables and was mains should be avoided wherever possible.

(iii) Sufficient overlap of cables shall be allowed for making the joints.

(iv) The joint bay should be sufficient dimensions to allow the jointers to work with as much freedom of movement and comfort as possible. Sufficient space should be kept below the cable to be jointed. **3 ph link box for cross bonding to be placed inside the bay with provision for easy access for maintenance purpose.**

(v) The joints of different phases shall be staggered in the jointing bay.

(vi) Comprehensive jointing instructions should be obtained from the manufacture of jointing kits and meticulously followed.

(vii) The materials used in the joints like ferrules, screen/ sheath continuity bonds, lugs etc. shall be of good quality and conform to standards.

(viii) The jointing tools shall be appropriate and as per the requirement of jointing HVXLPE cables.

(ix) SUMPHOLES

When jointing cables in water logged ground or under unforeseen rainy conditions, a sumphole should be made at one end of the joint bay, in such a position so that the accumulated water can be pumped or drained out by buckets, without causing interference to the jointing operation.

(x) TENTS/COVERS

An enclosure or suitable protection cover shall be used in all circumstances wherever jointing work is carried out in the open irrespective of the weather conditions. The joint shall be made in dust free, moisture free and clean atmosphere.

(xi) PRECAUTIONS BEFORE MAKING A JOINT

The cable end seals should not be opened until all necessary precautions have been taken to prevent circumstances arising out of rainy/ inclement weather conditions which might become uncontrollable.

If the cable end seals of cable ends are found to have suffered damage the cables should not be jointed, without tests and rectification.

(xii) MEASUREMENT OF INSULATION RESISTANCE

Before joining, the insulation resistance of both sections of cables shall be checked.

(xiii) The identification of each phase shall be clearly and properly noted. The cables shall be jointed as per the approved design. Each cable shall have identification for phase at joint bays.

20.33 BONDING OF SCREEN/ SHEATH

The screens at both ends, shall be brought out and bonded to the earth station through disconnecting type link boxes or through SVL wherever applicable. On the basis of the length of the cable and current carrying capacity, the bonding maybe required **as per IEEE 575** as follows:

1. Single End Bonding
2. Double End Bonding
3. Cross Bonding

4. Midpoint bonding

All accessories and consumables used in the termination should be of good quality and compatible with the cable. At the time of single end bonding parallel copper earth continuity conductor along the length of the cable shall have to be provided between the two ends of the cable. Bonding cable **of 1.1KV copper** XLPE insulated shall be provided for bonding of metallic sheath/ Screen.

The screens at both ends, shall be brought out and bonded to the earth station through disconnecting type link boxes or through SVL wherever applicable. On the basis of the length of the cable and rise of sheath Voltage the bonding maybe required as follows:

1. Single End Bonding
2. Double End Bonding
3. Cross Bonding
4. Mid point bonding

All accessories and consumables used in the termination should be of good quality and compatible with the cable. At the time of single end bonding parallel copper conductor along the length of the cable shall have to be provided between the two ends of the cable. Bonding cable of 6.6KV copper shall be provided for bonding of metallic sheath/ Screen.

20.34 CONNECTION OF RADIAL WATER BARRIER AND CABLE SCREEN

If the metallic radial water barrier is insulated from the metallic wire screen a connection suitable to carry the currents occurring during operation must be installed between metallic radial water barrier of the cable and metallic wire screen in joints and sealing ends.

20.35 STATUATORY APPROVAL OF WORKS

Contractor shall make an application on behalf of the owner for submission to the Electrical Inspectorate along with copies of required certificates complete in all respects and submit to the engineer-in-charge for onward transmission well ahead of time so that the actual commissioning of system/ equipment is not delayed for want of inspection by the Inspector. Contractor shall arrange the actual inspection of work by the Electrical Inspector. Necessary coordination and liaison work in this respect shall be the responsibility of the contractor.

The Inspection and acceptance of work as above shall not absolve the Contractor from any of his responsibilities under this contract.

Any other statutory approval of works required for the electrical installation (such as Factory Inspector, CCOE, etc.) is also included in contractor’s scope.

Supply & execution of job is subjected to regulations time to time framed by the AERC; approval Govt. Of Assam, and NOC from Assam Pollution Control Board. Contractor shall complete the entire job in compliance with the same.

20.36 INSPECTION, TESTING AND COMMISSIONING

20.36.1 Inspection of Supplied materials and Site works time to time during execution: Inspection of AEGCL and clearance from AEGCL will be in Contractor responsibility. Expenditure related to this inspection will be in contractor account. Site inspection, testing and commissioning of electrical installation shall be carried out as per enclosed Specification and Inspection and Test Plans included or referred in this BID. All the equipment installed by the contractor shall be tested and commissioned, as required and no separate payments shall be made unless otherwise specified in the Schedule of Rates. Contractor shall carefully inspect all equipment and submit the manufacturer’s Certificate before installation. Any damage or defect noticed shall be brought to the notice of the engineer-in-charge at that time and same shall be rectified or replaced by CONTRACTOR on his OWN RISK AND COST within TIME FRAME. Complete testing of power transmission system would be carried out under the supervision of the Employer.

20.36.2 Any work not conforming to the execution drawings, specifications or codes shall be rejected forthwith and the contractor shall carry out the rectification at his own cost.

20.36.3 The contractor shall carry out all the tests as enumerated in the tender and technical specifications and technical documents which may be furnished to him during performance of the work.

20.36.4 Before the electrical system is made live, the electrical contractor shall carry out suitable tests to establish to the satisfaction of the Employer that the installation of equipment, cabling/ wiring and connections have been correctly done and are in good working condition and that the system/ equipment will operate as intended.

20.36.5 All tests shall be conducted in the presence of Employer/ Engineer-in-Charge or his authorized representative unless he waives this requirement in writing. Contractor shall arrange testing equipment, as required to carry out the tests. Test results shall be recorded on approved Performa and certified records of the tests shall be submitted to the Employer/ Engineer-in-Charge.

20.36.6 Prior intimation to be given to the Employer before finalizing of date of scheduled inspection at least 15 days in advance.

20.36.7 Clearance in favour of contractor for dispatch of equipment/material from respective works of manufacturer will be covered by the Employer after physical inspection and witnessing satisfactory routine and acceptance tests. Contractor will have to arrange physical inspection and witnessing of Routine and Acceptance Test of materials/equipments at respective manufacturer’s works by two engineer of the Employer and cost of such inspection shall have to be borne by contractor. Clearance for dispatch of equipments & materials from respective works of manufacturers will be conveyed by the Employer after verification and acceptance thereafter.

20.36.8 After the completion of all tests and rectification of all defects pointed out during final inspection, plant start-up trials shall commence. During the start-up trials, contractor shall provide skilled/ unskilled personnel and supervision round the clock at his own cost. The engineer-in-charge/Employer will decide the number and the category of workmen and their duration. Any defects noticed during the start-up trials relating to the equipment supplied and work carried out by the contractor, shall be rectified by the contractor at his own cost.

20.36.9 The Employer shall have the right to get the defects rectified at the risk and cost of the contractor if he fails to attend to the defects immediately as desired.

20.36.10 Contractor shall also inform the Employer/ Engineer-in-charge, well in advance in case services of any OEM (Equipment manufacturer) are required and same shall be arranged by Contractor at the time of commissioning on his own cost.

20.36.11 Contractor shall furnish site acceptance test (SAT) procedures from the equipment supplier and get it approved from the Employer/ Engineer-in-charge before carrying out the same at site.

20.36.12 Contractor shall prepare detailed testing, pre-commissioning and commissioning procedures for the entire installation. These shall include Performa for defining activities and recording of test results.

20.36.13 It is the responsibility of the contractor to coordinate and provide all necessary assistance to other contractors / agencies/ vendors involved in the complex for proper and timely execution of the works. Further contractor shall do all the liaisoning, documentation or other related formalities with respective authorities/agencies for successfully charging/commissioning of system.

20.36.14 The following equipment/ items as included in Contractor’s scope of supply shall be tested and inspected by AEGCL or his authorized representative before dispatch at the manufacturer’s works. Test certificates duly signed by AEGCL or his authorized representative shall be submitted by the contractor as part of the final document:

a) EHV cable & optical fiber cables and Linear Heat sensing cable.

b) Jointing & termination kits for above items.

20.37 ENGINEERING DATA AND DRAWINGS

The Bidder shall necessarily submit all the drawings/ documents unless anything is waived. The Bidder shall submit 4(four) sets of drawings/ design documents/ data/ test reports as may be required for the approval of the Employer.

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

All engineering data submitted by the Bidder after final process including review and approvalbytheEmployershallformpartoftheContractDocumentandtheentireworks performed under these specifications shall be performed in strict conformity, unless otherwise expressly requested by the Employer in Writing.

20.38 INSTRUCTION MANUAL

(i) 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.

(ii) If after the commissioning and initial operation, the instruction manuals require any modifications/ additions/ changes, the same shall be incorporated by the bidder in the final submission.

(iii) The Bidder shall furnish to the Employer catalogues of spare parts.

20.39 QUALITY ASSURANCE PROGRAMME

a. To ensure that the equipment and services under the scope of this Contract whether manufactured or performed within the Bidder's Works or at his sub-bidder's premises or at the Employer's site or at any other place of work are in accordance with the specifications, the Bidder shall adopt suitable quality assurance programme to control such activities at all points necessary. Such programme shall be outlined by the Bidder and shall befinally accepted by the Employer after discussions before the award of Contract.

b. Quality Assurance Documents

The Bidder shall be required to submit the following Quality Assurance Documents within three weeks before laying/ erection of the equipment.

(i) All Non-Destructive Examination procedures, stress relief and weld repair procedure actually used during fabrication and reports including radiography interpretation reports.

(ii) Welder and welding operator qualification certificates.

(iii) Welder's identification list, listing welder's and welding operator's qualification procedure and welding identification symbols.

(iv) Raw material test reports on components as specified by the specification and/or agreed to in the quality plan.

(v) Stress relief time temperature charts/ oil impregnation time temperature charts.

(vi) Factory test results for testing required as per applicable codes/ mutually agreed quality plan/ standards referred in the technical specification.

(vii) The quality plan with verification of various customer inspection points (CIP) as mutually agreed and methods used to verify the inspection and testing points in the quality plan were performed satisfactorily.

20.40 EQUIPMENTS & STRUCTURES FOR CABLE TERMINATION

1. The terminating structure being provided should be designed as per the requirement of the cable end sealing, porcelain bushing etc. The mounting structure shall be fixed on the cement concrete

foundation, the design and drawings of which shall be submitted to Employer for review and acceptance during the course of detailed engineering.

After fixing the end termination, the cable shall be fixed to the support, with non- magnetic material clamps to the required height securely. The mounting structure includes the supports for cable end boxes, link boxes and any other structure required for the intent of the contract. All steel sections used shall be free from all imperfections, millscales, slag intrusions, laminations, fillings, rust etc. that may impair their strength, durability and appearance. All materials shall be of tested quality only unless otherwise permitted by the Employer.

2. Suitable fencing should be provided at the cable terminating yard at cable conductor junction point. The fencing will consist of galvanized steel XPM structure over a brick wall of 2(two) feet meeting electrical requirement (IE). A suitable entry point (gate) has to be provided.
3. Outdoor type lightning arresters for each cable of both the circuits are to be provided at cable-conductor junction point. The technical specification of lightning arresters is given separately in this volume.
4. It is recognized that the Bidder 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 the Employer. Unless brought out clearly, the Bidder shall be deemed to conform to this specification scrupulously. All deviations from the specification shall be clearly brought out in the respective schedule of deviations. Any discrepancy between the specification andthe catalogues or the bid, if not clearly brought out in the specific requisite schedule will not be considered as valid deviation.

5. Equipment furnished shall be complete in every respect with all mountings, fittings, fixtures and standard accessories normally provided with such equipment and/or needed for erection, completion and safe operation of the equipment as required by applicable codes though they may not have been specifically detailed in the Technical Specifications unless included in the list of exclusions. Materials and components not specifically stated in the specification but which are necessary for commissioning and satisfactory operation of the work 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.

6. STEEL STRUCTURES (GANTRY, EQUIPMENTS ETC.):

A) The contractor shall assume full responsibility for supply, fabrication and detailing, if required of the steel structures and for their satisfactory performance. All detail drawings for the structures shall be supplied to the successful bidder by the Employer/Engineer. However, the contractor shall have to submit the construction drawings to the Engineer/Employer solely prepared on the basis of these supplied drawings. Equipment Structure drawings, supplied by the employer, shall have to be modified to suit to the approved GA drawings of the equipment and electrical layout drg. And to be submitted to Engineer for approval. Employer/ Engineer shall have the right to instruct the contractor to make any changes in details necessary to make the construction conform to the requirement of the Contract Document.

B) The contractor shall supply all materials, deliver the same to site, and provide all labour, erection plant and equipment, fixtures, fitting and all temporary and permanent works necessary for satisfactory completion of the job in all respects.

C) No omissions or ambiguities on the drawings or in specifications will relieve the contractor from furnishing best quality of materials and workmanship. Should any inaccuracies be found, the contractor shall promptly notify the Employer/Engineer without carrying out the job and no further work shall be done before these discrepancies are corrected. Continuation of further work shall be done only after such discrepancies are rectified at contractor's risk and responsibility.

D) MATERIALS: The materials shall conform to the following requirements:

All Structural Steel Materials to be used in construction within the purview of the specification shall comply with :IS:2062 –Structural Steel (Grade-A) (fusion welding quality) and manufactured by Prime Rollers e.g. SAIL/ TISCO/ IISCO/ RINL. In case of MS sections not manufactured by prime rollers or such sections are not available with prime rollers the same is to be procured from approved conversion agents of prime manufacturer(s).In such case, prior approval of the Engineeris to be obtained by the contractor.

Successful bidder on receipt of structural drawing from department shall submit within 15 days, a detailed raw material procurement plan indicating MS sectionwise producers name to the Engineer for approval. On according approval in this aspect, work for fabrication protos shall be taken up in hands.

Entire fabrication job of MS structural shall not be entrusted to more than two sub- vendors. Further, a list of bonafide fabricators, not exceeding 6 (six) shall be furnished to the Engineer for according approval within 15(fifteen) days from the date of handing over of drawings.
All electrodes to be used under the contract shall comply with any of the following Indian Standard Specifications as may be applicable.

i) IS:814: Covered electrodes for metal arc welding of Structural Steel.

ii) IS:815: Classification and coding of covered electrodes for metal arc welding of mild steel and low alloy high tensile steel.

iii) IS:144: Covered electrodes for the metal arc welding of high tensile structural steel.

All bolts and nuts shall be of grade 5.6HRH and shall conform to the requirements of IS:6639 and IS:1367 and galvanizing quality shall be as per IS:1367. All bolts and nuts shall be of minimum diameter of 16mm unless otherwise stated. All mildsteel for bolts and nuts when tested in accordance with the following Indian Standard specification shall have a tensile strength of not less than 44Kg/Sq.mm. and a minimum elongation of 23 percent on a gauge length of 5.6A, where `A' is the cross sectional area of the test specimen-

i) IS:1367: Technical supply conditions for threaded fasteners.
ii) IS:1608: Method for tensile testing of steel products other than sheet, strip, wire and tube.

Washers shall be made of steel conforming to IS:226, IS:961 as may be applicable under the provisions of the contract and shall be electrogalvanized.

7 FASTNERS & CONNECTIONS:

a) BOLTS: All connections shall be bolted with 16mm bolts.

b) SPLICES: Splicing shall be avoided unless the length of a member exceeds 6.0 m or so. The member of splices shall be limited to a practical minimum. No credit shall be allowed for bearing on a butting areas. Lap joints in leg members shall be preferred to butt joints.

c) STEP BOLTS: Step bolts shall be of 16mm diameter and shall have round or hexagonal head. Each step bolt shall be provided with two hexagonal nuts. The minimum bolt length and length of unthreaded portion shall be 180 and 125mm respectively. Step bolts shall not be used as connection bolts. The step bolts shall be spaced alternately on the inner gaugelineoneachfaceoftheangleabout40cmcenters.Theyshallbefurnished for one leg of each steel structure column from its base elevation.

d) U – BOLTS: U-Bolts shall be suitable furnished or steel structures to suspend or terminate insulator strings or ground wire assemblies. Size of U-bolt shall withstand all loads acting on it.

e) BILL OF MATERIAL: Bill of material shall give the size, length and weight of each member and the total weights of steel structures. It shall also include the number of bolts, nuts and washers per structure.

20.41 MATERIAL/ WORKMANSHIP

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.

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 Bidder 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 Bidder.

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.

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.

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.

Provision for Exposure to Hot and Humid climate: Outdoor equipment supplied under the specification shall be suitable for service and storage under tropical conditions of high temperature, high humidity, heavy rainfall and environment favourable to the growth of fungi and mildew.

20.42 PACKAGING & PROTECTION

a. 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 Bidder shall also submit packing details/ associated drawing for 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 in India should be taken into account. The Bidder 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, railway etc. shall be to the account of the Bidder. Employer takes no responsibility of the availability of the wagons.

b. 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 damaged. The parts which are likely to get rusted, due to exposure to weather should also be properly treated and protected in a suitable manner.

20.43 FINISING OF METAL SURFACES

a. 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 and bolts and spring washers shall be electro galvanized to service condition. All steel conductors including those used for earthing/grounding (above ground level) shall also be galvanized accordingtoIS:2629.

b. HOT DIP GALVANISHING

The minimum weight of the zinc coating shall be **900gm/sq.m** and minimum thickness of coating shall be **130 microns for outdoor and minimum thickness of coating shall be 85 microns for indoor for all items thicker than 6mm.** 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 610gm/sqm minimum.

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

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.

The galvanized steel shall be subjected to six one minute dips in copper sulphate solution as per IS-2633.

Sharp edges with radii less than 2.5mm 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

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.

d. PAINTING

i) All sheet steel work shall be degreased, pickled, phosphate in accordance with the IS-6005 “Code of practice for phosphating iron and sheet”. All surfaces which will not be easily accessible after shop assembly shall be forehand be treated and protected for the life of the equipment.

ii) The surfaces, which are to be finished painted after installation or require corrosion protection until installation shall be shop painted with at least two coats of primer. Oil, grease, dirt and swaf shall be thoroughly removed by emulsion cleaning. Rust and scale shall be removed by pickling with dilute acid followed by washing with running water, rinsing with slightly alkaline hot water and drying.

iii) 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.

iv) 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.

v) The exterior color of the paint shall be as per shade no: 697 of IS-5 and inside shall be glossy white for all equipment, marshalling boxes, junction boxes, control cabinets, panels etc. unless specifically mentioned under respective sections of the equipments. Each coat of primer and finishing paint shall be slightly different shade to enable inspection of the painting. A small quantity of finishing paint shall be supplied for minor touching up required at site after installation of the equipments.

vi) In case the Bidder proposes of follow his own standard surface finish and protection procedures or any other established painting procedures like electrostatic painting etc. the procedure shall be submitted along with the Bids of Employer’s review and approval.

20.44 HANDLING, STORING AND INSTALLATION

a. In accordance with the specific installation instructions as shown on manufacturer’s drawings or as directed by the Employer or his representative, the Bidder shall unload, store, erect, install, wire, test and place in to commercial use all the equipment included in the contract. Equipment shall be installed in a neat, workman like 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.

b. Bidder 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. Bidder 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.

c. In case of any doubt/ misunderstanding as to the correct interpretation of manufacturer’s drawings or instruction, necessary clarifications shall be obtained from the Employer. Bidder shall be held responsible for any damage to the equipment consequent to not following manufacturer’s drawings / instructions correctly. Where material/ equipment is unloaded by Employer before the Bidder arrives at site or even when he is at site. Employer by right can hand over the same to Bidder and there upon it will be the responsibility of Bidder to store the material in an orderly and proper manner.

d. The Bidder shall be responsible for making suitable indoor storage facilities to store all equipment, which require indoor storage.

e. The words ‘erection’ and ‘installation’ used in the specification are synonymous.

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

g. 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 Bidder shall immediately proceed to correct the discrepancy at his risks.

20.45 QUALITY CONTROL:

a. The contractor shall establish and maintain quality control procedures for different items of work and materials to ensure that all work is performed in accordance with the specifications and best modern practice.

b. In addition to the Contractor's quality control procedures, materials and workmanship at all times shall be subjected to inspection by the Engineer. As far as possible all inspection by the Engineer or Engineer's representative shall be made at the Contractor's fabrication shop whether located at site or elsewhere. The contractor shall cooperate with the Engineer in permitting access for inspection to all places where work is being done and in providing free of cost of all necessary help in respect of tools and plants, instrument, labour and material required to carry out the inspection. Materials or workmanship not in reasonable conformance with the provisions of this specification may be rejected at any time during the progress of the work.

c. The quality control procedure shall cover but not be limited to the following items of work :

d. Steel: Quality, manufacturer's test certificates, test reports including procurement in-voice of representative samples of materials from unidentified stocks if permitted to be used.

e. Bolts, nuts & Washers: Manufacturer's certificate, dimension check, material testing

f. Electrodes: Manufacturer's certificate, thickness and quality of flux coating.

g. Welds: Inspection, X-ray, ultrasonic test, magnetic particle tests as required

h. Paints: Manufacturer's certificate, physical inspection reports.

i. Galvanizing: Tests in accordance with IS:2633 – Method of testing uniformity of coating on zinc coated articles and IS:2629 Recommended practice for hot - dip galvanizing of iron and steel. Raw zinc & samples collected from bath shall be tested at third party laboratory as per direction of the Engineer.

j. The contractor shall submit a detailed material inspection plan on the basis of various IS codes & standard practices in respect of structural fabrication, galvanization, bolts, nuts, anchor bolts etc. much prior to commencement of the job.

20.44 FABRICATION WORKMANSHIP:

20.44.1 All workmanship shall be equal to the best practice in modern structural shop and shall conform to the provisions of IS:800/ IS:802.

20.44.2 Rolled materials before being laid off or worked, must be clean free from sharp kinks, bends, or twists and straight within the tolerances allowed by IS:1852. If straightening is necessary it may be done by mechanical means or by the application of a limited amount of localised heat not exceeding $600^{o}C$.

20.44.3 Cutting shall be effected by shearing, cropping or sawing. Use of mechanically controlled Gas Cutting Torch may be permitted for mild steel provided special care is taken to leave sufficient metal to be removed by machining, so that all metal that has been hardened by flame is removed. To determine the effective size of members cut by gas, 3mm shall be deducted from each cut edge.

20.44.4 The erection clearance for cleated ends of members connecting steel to steel shall preferably be not greater than 2mm at each end. The erection clearance at ends of beams without cleats shall not be more than 3mm at each end, but where for practical reasons greater clearance is necessary, suitably designed clearance shall be provided.

20.44.5 All members shall consist of rolled steel sections.

20.44.6 Holes for bolts shall not be more than 1.5mm larger than the diameter of the bolt passing through them unless otherwise stated.

20.44.7 All members shall be cut to jig and all hole shall be punched and drilled to jig. All parts shall be carefully cut and holes accurately located after the members are assembled and tightly clamped or bolted together.

20.44.8 Drifting or rimming of holes shall not be allowed. Holes for bolts shall not be formed by gas cutting process.

20.44.9 Punching of holes will not be permitted for M.S. members upto 8mm thick and in no case shall a hole be punched where the thickness of the material exceed the diameter of the punched hole.

20.44.10 Minimum bolt spacing and distances from edges of members shall in accordance withthe provisions in the relevant Indian Standard Specification.

20.44.11 Built members shall, when finished, be true and free from all kinds of twists and open joints and the material shall not be defective or strained in any way.

20.44.12 All bolts shall be galvanized including the threaded portion except the foundation bolts for which galvanizing work shall be done for a length of 100mm (min) to 175mm (max) measured from the tip of the treaded portion. The threads of all bolts shall be cleared of smelter by spinning or brushing. A die shall not be used for cleaning the threads unless specially approved by the Engineer. All nuts shall be galvanized with the exception of the threads which shall be oiled. In case of foundation bolts the same shall be galvanized excepting the length of embedment.

20.44.13 When in position all bolts shall project through the corresponding nuts but not exceeding 10 mm. The nuts of all bolts attaching insulator sets and earth conductor clamps to the structure shall be carefully positioned as directed by the Engineer.

20.44.14 Bolts and nuts shall be placed in such a way so that they are accessible by means of an ordinary spanner.

20.44.15 Foundation bolts shall be fitted with washer plates or anchor angles and flats, nuts etc. and shall be manufactured from mild or special steel.

20.44.16 Washers shall be tapered or otherwise suitably shaped, where necessary to give the heads and nuts of bolts a satisfactory bearing. The threaded portion of each bolt shall project out through the nut at least by 3mm. In all cases the bolt shall be provided with a washer of sufficient thickness under the nut. In addition to the normal washer, one spring washer or lock nut shall be provided for each bolt for connections subjected to vibrating forces or otherwise as may be specified in the drawings.

20.44.17 The thickness of spring washer shall be 3.5 mm for bolt diameter 16 mm and 4 mm for bolt diameter 20 mm.

20.45 CLEANING & GALVANIZING:

20.45.1 CLEANING:

After fabrication has been completed and accepted, all materials shall be cleared off rust, loose scale, dirt, oil grease and other foreign substances.

20.45.2 GALVANIZING:

All materials shall be hot-dip galvanized after fabrication and cleaning. Re tapping of nuts after galvanizing is not permitted.

Galvanizing for structural mild steel products shall meet the requirements of IS:4759. All holes in materials shall be free of excess spelter after galvanizing.

Galvanizing for fasteners shall meet the requirements of IS:1367. The spring washers shall be electrogalvanized as per IS:1573.

Finished materials shall be dipped in to the solution of dichromate after galvanizing for white rust protection during transportation.

All galvanizing shall be uniform and of standard quality. Quantity of zinc shall meet the requirement of IS:209.

Mass of Zinc Coating:

The mass of zinc coating for different class of materials, as given in Table below, shall be followed:

MASS OF ZINC COATING

Sl. No.	Product	Electro meter reading (micron)	Minimum value of average mass of coating

i)	Casting - gray iron, malleable iron		610 (gm/m2)
ii)	Fabricated steel articles :		
a)	5 mm thick and over	86	610
b)	Under 5 mm, but not less than 2 mm	65	460
c)	Under 2 mm, but not less than 1.2mm	48	340
iii)	Threaded work other than tubes and tube fittings :		
a)	10 mm dia and over	43	300
b)	Under 10 mm dia	39	270
iv)	All Outdoor structures	130	900

Technical Specification of Distributed Temperature Monitoring System (DTS)

The bidder shall include and provide separate “Distributed Temperature Monitoring System (DTS)” for entire route for EHV Cables complete in all respects along with terminal coupling equipment, workstation and required hardware and software for real time monitoring of conductor temperature profile (with ambient temperature compensation) and to provide dynamic power load predictions of the cable based on relevant IEC standards. The offered system should be able to provide maximum possible transmission capacity of the cable for each circuit. The distributed temperature monitoring system shall be optical fiber based, must be of proven technology and should be in operation for similar use along with EHV cables as per latest practices. The DTS shall be inherently resistant to taking a given reading and giving a false alarm due to the requirement for multiple physical effects (Viz. temperature/hot spot, strain, arc flash, optical Loss, Fiber Break, Conductor break, etc.) to simultaneously occur at the same location to signify an event and trigger an alarm with Geo-tags. The DTS system can be calibrated to run very quick (a few seconds), lower accuracy (±1°C) scans of the fibre for temperature changes or to take a slower (half a minute) more detailed scan for maximum accuracy (±0.25°C) of temperature to sense even the smallest changes. The DTS shall be passive, no electricity is required in the field. Also, no maintenance or calibration shall be required after commissioning. The self-diagnostics of DTS shall monitor the unit’s condition and maintain optimum performance. The DTS shall not be affected by electromagnetic fields (EMF), lightning or weather events. The DTS unit can be attached as a loop to both channels on independent fibres and in the event of a cut will report the damage, but continue to monitor the fiber on both sides up to the cut. The “terminal coupling equipment” and “workstation” shall preferably be microprocessor based with HMI, for displaying temperature along the length of the cable system. System shall provide potential free output contact for signaling to SCADA. The bidder shall provide brochures and catalogues for offered distributed temperature monitoring system along with the bid. Optical fiber cables along with all joining accessories etc. required for DTS shall also be included in the scope of bidder. Optical fiber cable associated with DTS shall be laid in the same EHV cable trench/raceway.

General Technical Specifications of DTS

(All blank parameters shall be filled-up by Vendor/EPC)

Sl. No.	Parameter	Description
1.	Sensing Element	Fibre Optic Sensing Cable
2.	Number of channels (Dual Channel)	
3.	Interrogator operating Temperature	0-50°C
4.	operating Humidity (max)	As per GTR
5.	Dimensions (Rack mounted)	
6.	Weight (Kg)	
7.	Power Supply (V)	

8.	Power consumption (W)	
9.	Sensing Range (DTS) (km) Loop Per channel	
10.	Spatial Resolution (250 or 500mm)	
11.	Frequency Response	1Hz-120kHz (Range Dependant)
12.	Temperature sensing range (cable)	-5°C to 700°C
13.	Accuracy	
14.	Resolution	
15.	Scan Time	
16.	Light Source	Laser (Infra-red) Class 1M
17.	Laser Wave Length	As per IEC
18.	Laser Stability	As per IEC
19.	Acquisition rate	
20.	Processor Acquisition Rate	64Bit (Ultra high speed)
21.	Operating System	
22.	Output	Modbus, Ethernet, TCP/IP (Standard), Relay, USB, SCADA, IEC 61850
23.	Remote Interfacing	Ethernet and 4G/5G enabled
24.	Processer architecture	Field programmable gate array (FPGA)
25.	Data Storage (Removable)	2x 2TB HDD (removable) [Minimum]
26.	Data Storage (Internal)	128GB Solid State Drive [Minimum]
27.	Dynamic Range	
28.	Standard	IEC 61757-2-2: 2016 and other relevant IEC
29.	Any other parameters to be filled by Manufacturer	
30.	Firmware and software details (Latest Version)	
31.	Warranty Period	
32.	License validity period (if any)	
33.	Measurement reach (km)	

Table 2: CHAPTER 26: SPECIFICATION FOR DESIGN AND FABRICATION OF SU B STATION STEEL STRUCTURES

STRAIGHTENING AFTER GALVANIZING:

All plates and shapes which have been warped by the galvanizing process shall be straightened by being rerolled or pressed. The materials shall not be hammered or otherwise straightened in a manner that will injure the protective coating. If, in the opinion of Employer/ Engineer the material has been forcibly bent or warped in the process of galvanizing of fabrication, such defects shall be cause for rejection.

REPAIR OF GALVANIZING:

Materials on which galvanizing has been damaged shall be acid stripped and re-galvanized, unless, in the opinion of Engineer, the damage is local and can be repaired by zinc spraying or by applying a coating of galvanizing repair compound. Where re-galvanizing is required, any member which become damaged after having been dipped twice shall be rejected.

SHOP ASSEMBLY:

One of each type of steel structures shall be assembled in the shop to such an extent as to ensure proper field erection in order to facilitate inspection by the Engineer.

SHOP TEST:

The following shop tests shall be performed with relevant provisions of I.S. Codes :

a) *General Inspection*
b) *Material test.*
c) *Assembly test.*
d) *Galvanizing test.*

The contractor shall furnish four certified copies of reports of all tests to the Engineer.

20.46 DESIGN OF FOUNDATIONS:

20.46.1 STEEL STRUCTURE FOUNDATIONS:

The foundations shall be designed such that the upper structure shall be securely supported. Any unequal displacement that may cause harmful effect to the upper structures shall not be allowed. The safety factors for strength and stability of the foundations shall be as per relevant code.

The overload factor shall be taken as 1.1 for designing foundations of all gantry and equipment. The loads, shear and moment values shall be multiplied with this overload factor, so as to obtain the design values

20.49 WEIGHT OF SUB-STATION STRUCTURES:

Self-weight of line tower, A-frame and equipment structures for different gantry and equipment structures shall be provided at the time of detail engineering.

20.50 Technical Specification for Underground Fibre Optic Cable

This section describes the functional requirements, major technical parameters and Type testing, Factory Acceptance Testing & Site Acceptance Testing requirements for underground fibre optic cables and HDPE pipes. Marking, packaging, transportation & installation requirements have also been described. The payment will be made for the executed route length only. However, specified service loops and lengths for wastage, installation/working for FO cable & HDPE ducts shall be considered as required by the bidder for which no additional payment will be made.

20.50.1 General

The underground fibre optic cable shall be armoured and shall be suitable for direct burial as well as for underground installation in pipes. The cable should be of low weight, small volume and high flexibility. The mechanical design and construction of each unit shall be inherently robust and rigid under all condition of operation, adjustment, replacement, storage and transport. The fibre optic cable shall be a UV resistant, rodent proof. The underground fibre optic cable (UGFO) shall be offered from a manufacturer who has been manufacturing UGFO for the last five (5) years and UGFO manufactured & supplied by such manufacturer shall have been in satisfactory operation.

20.50.2 Applicable Standards

The cable shall conform to the standards named below and the technical specifications described in the following sections.

i). ITU-T Recommendations G.652

ii). Electronic Industries Association, EIA/TIA 455-78A, 455-3A/33/41/25A / 81A / 82B, 455-62A, 455-164A/167A/174, 455-168A/169A/170/175A, 455-176, 455-59, EIA/TIA 598, EIA 455- 104.

iii) International Electro technical Commission standards, IEC60304, IEC60794-1-2, IEC60811-5-

iv) Bellcore GR-20

v) Indian Railways standard specification no IRS:TC55(Oct 96) (including all amendments)

vi) ASTM:A167-92,ASTM:751-92b,ASTM:A751-92,ASTM:A370-82,ASTM:D2581-

91,ASTM:D2287-81, ASTM:D 638 for FRP, ASTM :D 217,556, 93-IP-34 for Jelly, ASTM:D

570,211 for PBTP, ASTM:D1505for Poly Carbonate, ASTM:D1633,150 for HDPE.

20.50.3 Fibre Type(s) and Counts

The Cable shall consist of 24 fibres Dual-Window Single mode (DWSM), G.652 optical fibres and shall meet the requirements stipulated in Table 1

DWSM Optical Fibre Characteristics(Table-1)

Fibre Description:	Dual-Window Single-Mode

Mode Field Diameter:	8.6 to 9.5 µm (± 0.6 µm)
Cladding Diameter:	125.0 µm +/- 1 µm
Mode Field concentricity error	≤0.6%
Cladding non-circulatory	≤ 1%
Cable Cut-off Wavelength λ_{cc}	≤ 1260 nm
1550 nm loss performance	As per G .652
Proof Test Level	≥ 0.69 Gpa
Attenuation Coefficient:	@ 1310 nm ≤ 0.35 dB/km @ 1550 nm ≤ 0.21 dB/km
Chromatic Dispersion; Maximum: **Zero Dispersion Wavelength:** **Zero Dispersion Slope:**	18 ps/(nm x km) @ 1550 nm 3.5 ps/(nm x km) 1288-1339 nm 5.3 ps/(nm x km) 1271-1360 nm 1300 to 1324 nm 0.092 ps/(nm^2xkm) maximum
Polarization mode dispersion Coefficient	≤0.2 ps/km$^{\wedge 1/2}$
Temperature Dependence:	Induced attenuation ≤ 0.05 dB (-60^{0}C - + 85^{0}C)
Bend Performance:	@ 1310 nm (75±2 mm dia Mandrel), 100 turns; Attenuation Rise ≤0.05 dB @ 1550 nm (30±1 mm radius Mandrel) 100 turns; Attenuation Rise ≤ 0.05 dB @ 1550 nm (32±0.5 mm dia Mandrel, 1 turn; Attenuation Rise ≤ 0.50 dB

20.50.4 General Cable Construction

Consist of a central fibre optic unit protected by one or more layers of helically wound anti-hygroscopic tape or yarn. The central fibre optic unit shall be designed to house and protect the fibres from damage due to forces such as crushing, bending, twisting, tensile stress and moisture, wide temperature variations, hydrogen evolution etc. The fibre optic unit shall be of loose tube construction. The inner polyethylene jacket and outer sheath jackets shall be free from pinholes, joints, splits or any other defects. All fibre optic cable shall have a minimum service life span of 25 years. The cable construction and mechanical parameters for the Armoured OFC shall be as specified in the Table 2 below.

Table 2

Armoured Cable Construction and Mechanical Parameters

Parameter	Units	Description
No of fibres in the cable		24
Type of fibres in the cable		G.652
No. of loose tubes		Minimum 2
Cable design life		More than 25 years

20.50.5 Colour Coding & Fibre Identification

Individual optical fibres within a fibre unit, and fibre units shall be identifiable in accordance with EIA/TIA 598 or IEC 60304 or Bellcore GR-20 colour-coding scheme. The colour coding system shall be discernible throughout the design life of the cable. Colouring utilized for colour coding optical fibres shall be integrated into the fibre coating and shall be homogenous. The colour shall not bleed from one fibre to another and shall not fade during fibre preparation for termination or splicing. Each cable shall have traceability of each fibre back to the original fibre manufacturer's fibre number and parameters of the fibre. If more than the specified number of fibres are included in any cable, the spare fibres shall be tested by the cable manufacturer and any defective fibre shall be suitably bundled, tagged, and identified at the factory. The colouring scheme shall be submitted along with the cable DRS/drawing for Employer's approval.

20.50.6 Strength Members

The armoured optical fibre cable shall have solid non-metallic strength member(s)/ Solid metallic member(s) or the combination of both. The metallic strength member shall be of high grade steel wire, music spring quality as per ASTM-A228/A228M-93 and shall have suitable chemical coating for proper adhesion with sheath material. The central fibre optic unit should include a central strength member of non-metallic Fibre Reinforced Plastic (FRP) only. Peripheral strength members and aramid yarns are also acceptable. The central FRP strength member may be of slotted type with SZ lay (reverse oscillation lay) of fibre units or it may be cylindrical type with helical or SZ lay of fibre units. The construction of the central strength member shall be such as to meet the mechanical strength requirements specified in this specification.

20.50.7 Filling Compound

The interstices of the central fibre optic unit and cable shall be filled with a suitable compound to prohibit any moisture ingress or any longitudinal water migration within the fibre optic unit or along the fibre optic cable. The water tightness of the cable shall meet or exceed the test performance criteria as per **IEC60794-1-2-F5**. The filling compound used shall be a non-toxic homogenous waterproofing compound that is free of dirt and foreign matter, anti-hygroscopic, electrically nonconductive and non-nutritive to fungus. The compound shall also be fully compatible with all cable components it may come in contact with and shall inhibit the generation of hydrogen within the cable. The filling compound shall remain stable for ambient temperature up to +70°C and shall not drip, flow or leak with age or at change of temperature. Reference method to measure drip point shall be as per **IEC 60811-5-1** and drip point shall not be less than 70°C.

20.50.8 The Sheath / Inner jacket

The Sheath shall be made of High Density Polyethylene-HDPE (Red /Black) and shall be smooth, concentric, and free from holes, splits, blisters and other surface flaws. The sheath shall be extruded directly over the central fibre optic unit and shall also be non-hygroscopic. The cable sheath design shall permit easy removal without damage to the optical fibres or fibre units. The sheath shall be made from good quality of weather resistant polyethylene compound HDPE and thickness shall be > 1.5mm including the strength member if used in the sheath.

20.50.9 Armouring of cable

Over the inner PE sheath armouring and outer sheath shall be provided to make the cable termite and rodent proof. The thickness of the stainless steel alloy armour shall be > 0.125mm. The steel armour shall be both side coated with a copolymer of thickness > 0.05mm so as to bond the armouring to the outer jacket and make a unitary construction. Stainless steel shall be armouring corrugated transversely for lateral strength and bending flexibility to be applied longitudinally with an overlap of 10% (minimum) over the inner PE sheath. The corrugation over the entire length of the tape used in the cable shall be uniform, electrically continuous (applicable to all metallic elements used in the cable) and bonded to the outer sheath. The force of adhesion of the armour to the outer sheath shall be minimum 14 Newton and shall be tested as per ASTM:4565 test method. Suitable glue adhesive should be provided in between overlap portion of cable armouring for bonding to avoid ingress of moisture (below the armour). The height of the corrugation shall be 0.6mm (min.) and the pitch shall be 2.5mm(max.). Height and pitch of corrugation shall be measured between crest and tough base line. The corrugated armouring of stainless steel shall offer excellent corrosive resistance and shall be AISI Alloy no. 304 and the chemical composition and mechanical properties of steel shall be as specified in table 1 & 2 of ASTM : A167-92b for AISI 304 respectively.

20.50.10 The Outer Jacket

A non-metallic moisture barrier sheath (Red or Black in colour) shall be applied over the armour, which shall consist of tough weather resistance made of HDPE. The thickness shall be uniform and shall not be less than 2.0mm (Red in colour) for the cable having inner and outer HDPE sheath. The outer jacket shall have smooth finish and shall be termite resistant. The raw material and additive used to make the outer sheath termite proof shall be clearly mentioned by the manufacturer of the cable.

In case of HDPE material black in colour is used, the material from finished product shall be subjected to the following tests mentioned in Table 3 below;

Table 3	
1.Density	0.94 to 0.965 gm/cc
2.Melt flow index	< 0.8 gm/10 minutes at 1900 C
3.Carbon black content	(2.5+0.5)%
4.Carbon black Dispersion	Uniform dispersion
5.ESCR	No crack till 48H in 10% Igepal solution 50^{0}C
6.Moisture Content	<0.3% for 24H, ASTM D570
7.Tensile strength and Elongation at break	>2 $Kg.mm^{2}$ and > 500% respectively

Rip Cord: Suitable rip cord(s) shall be provided to open the outer sheath of the cable. The rip cord(s) shall be properly waxed to prevent wicking action and shall not work as a water carrier.

20.50.11 Mechanical Parameters & Tests: The offered cable shall meet requirement of mechanical characteristic & tests specified in this specification.

20.50.12 Cable drums, Marking, Packaging and Transport

All optical fibre cable shall be supplied on strong wooden drums provided with lagging with adequate strength, constructed to protect the cabling against all damage and displacement during transit, storage and subsequent handling during installation. The cable drum shall be suitable to carry underground fibre optic cable of required length. However, the exact lengths for drums to be supplied for each link shall be determined by the Contractor during detailed engineering/survey. Drum schedule shall be approved by the Employer before manufacturing the FO cable. Both cable ends in the drum shall be sealed and shall be readily accessible. The drum shall be marked with arrows to indicate the direction of rotation. Both the ends of the cable shall be provided with pulling eye. The pulling eye and its coupling system should withstand the same tensile load as applicable to the cable. The following marking shall be done on each side of the cable drums.

i) Drum number
ii) Consignee's name and address
ii) Contractor's name and address
iv) Type of cable
v) Number of fibres
vi) Type of fibres
vii) Year of manufacturing, month & batch no
viii) Name of manufacturer
ix) Total cable length
x) Inner end marking and Outer end marking

Packing list supplied with each drum shall have all the information provided on marking on the respective cable drum and following additional information: OTDR length measurement of each fibre and Ratio of fibre and cable length.

20.50.13 Optical fibre cable marking

A suitable marking shall be applied in order to identify this cable from other cables. Marking on the cable shall be indelible, of durable quality, shall last long and shall be applied at regular interval of one-meter length. Marking shall be imprinted and must clearly contrast with the surface and colours used must withstand the environmental influences experienced in the field. The accuracy of the sequential marking must be within + 0.5% of the actual measured length. The sequential length marking must not rub off during normal installation. In case laser printing is used the marking shall not exceed 0.15 mm depth. The optical fibre cable shall have the following markings in every meter.

i) Type of Cable
ii) Running meter length
iii) Number of fibres
iv) Type of fibre
v) Laser symbol & caution notice
vi) Year of manufacture and batch no.
vii) Manufacturer's name
viii) Owner's Name

20.50.14 Operating Instructions

Complete technical literature in English with detailed cable construction diagram of various sub-component with dimensions and test data of the cable shall be provided. All aspects of installation shall also be covered in the handbook.

20.50.15 Test and Inspection:

`Type Testing

The Bidder shall offer only the type tested cable and submit along with their bid the earlier carried out type test reports for the offered fibre optic cable meeting the requirement. The Contractor shall submit the previously carried out type test report for the same design of cable for the tests listed in Table below. The fibre should have been type tested as per relevant International standards for the tests listed in Table below and the Bidder shall submit the test reports and certificates along with the bid. The Contractor shall submit the type test reports of fibres meeting the minimum requirement specified in Tables below.

Type Tests Fibre Optic Cable

TABLE-4

S. No	Test Name	Test Procedure
1	Water Ingres Test	(IEC 60794-1-F5/EIA 455-82B) Test duration:24 hours
2	Seepage of filling compound	(EIA 455-81A) Preconditioning: 72 hours, Test duration: 24 hours
3	Crush test	IEC 60794-1-E3/EIA 455-41)
4	Impact test	(IEC-60794-E4/ EIA 455-25A)
5	Stress strain Test	(EIA 455-33A)
6	Cable Cut-off wavelength	(EIA 455-170)
7	Temperature Cycling Test	(IEC60794-1-F1/EIA-455-3A)-2 cycles

Type Tests Fibre Optic Cable

TABLE-5

S. No	Test Name	Acceptance Criteria	Test Procedure
1	Attenuation	As per TS	IEC 60793-1-40 or EIA/TIA 455-78A
2	Attenuation Variation with wavelength		IEC 60793-1-40 or EIA/TIA 455-78A
3	Attenuation at Water Peak		IEC 60793-1-40 or EIA/TIA 455-78A
4	Temp Cycling (Temp dependence of Attenuation)		IEC 60793-1-52 or EIA/TIA 455-3A, 2 cycles

5	Attenuation with Bending (Bend Performance)		IEC 60793-1-47 or EIA/TIA 455-62A
6	Mode Field dia.	As per TS	IEC 60793-1-45 0r EIA/TIA 455-164A/167A/174
7	Chromatic dispersion		IEC 60793-1-42 or EIA/TIA 455-168A/169A/175A
8	Cladding Diameter		IEC 60793-1-20 or EIA/TIA 455-176
9	Point Discontinuities of attenuation		IEC 60793-1-40 or EIA/TIA 455-176
10	Core-Clad concentricity error		IEC 60793-1-20 or EIA/TIA 455-176
11	Fibre Tensile proof testing		IEC 60793-1-30 or EIA/TIA 455-31B

Factory Acceptance Testing

The tests listed in Table below shall be carried out as Factory Acceptance Test for Underground fibre optic cable meeting the requirements specified in this section.

Factory Acceptance Tests on Underground Fibre Optic Cable

Sl No	Factory Acceptance Test
1	Attenuation Coefficient (1310, 1550): By EIA/TIA 455-78A or OTDR
2	Point discontinuities of attenuation: By EIA/TIA 455-78A or OTDR
3	Visual Material verification dimensional checks as per approved drawings

20.51 PLB HDPE PIPE and ACCESSORIES

The following paragraphs describe the functional requirements, major technical parameters and Type and Factory Acceptance Testing requirements for Permanently Lubricant High Density Polyethylene (PLB HDPE) Pipe. PLB HDPE pipe shall be suitable for underground fibre optic cable installation by blowing as well as conventional pulling. The PLB HDPE pipe shall be suitable for laying in trenches by directly burying, laying through G.I/RCC hume pipe and laying through trench less digging. The expected service life of HDPE pipe and accessories shall not be less than 50 years. The unit rates quoted in the price schedule shall be the composite price of PLB HDPE pipe along with all accessories.

20.51.1 Construction of PLB HDPE pipe

The PLB HDPE pipe shall have two concentric layers viz. outer layer and inner layer. The outer layer shall be made of HDPE material and the inner layer of solid permanent lubricant. These concentric layers shall be co-extruded and distinctively visible in cross section under normal lighting conditions and generally conform to IS-9938. The colour of the PLB HDPE pipe shall be finalized during detail engineering. In the finished PLB HDPE pipe, the co-extruded inner layer of solid permanent lubricant shall be continuous and integral part with HDPE outer layer and preferably be white in colour. The inner layer of solid permanent lubricant shall not come out during storage, usage and throughout the life of the pipe. The pipe shall be supplied in a continuous length of 1000 (one thousand) meter in coil form, suitable for transportation, installation and handling purposes. The finished pipe shall be of good workmanship such that the pipe is free from blisters, shrink holes, flaking, chips, scratches, roughness, break and other defects. The pipe shall be smooth, clean and in round shape, without eccentricity. The ends shall be cleanly cut and shall be square with axis of the pipe.

20.51.2 General

The HDPE pipe shall conform to the following standard and the technical specifications described in the following sections.

a) IS: 4984 / IS: 2530/IS:14151/(part1)/ IS:9938/IS:7328/IS12235(Part-9)/IS:5175

b) ASTM D 1693/ ASTM D 638/ ASTM D 648/ ASTM D 790 / ASTM D 1712/

ASTM D 2240/ ASTM D 4565 / ASTM F 2160/ ASTM G 154

c) TEC-spec no. GR/CDS-08/02/NOV-04(including all amendments)-HDPE pipe for

use as duct for optical fibre cable.

20.52 Installation of Underground Fibre Optic Cable System

The Underground Fibre Optic Cable shall be installed along the power cable to be supplied & installed under this Project. This part of the section describes the installation procedures, installation of PLB HDPE pipes, installation of RCC hume pipes and GI Pipes, marking, backfilling, installation of underground FO cable, construction of manholes, splicing, termination and site acceptance testing requirements of the underground fibre optic cabling system.

20.52.4 Underground Fibre Optic Cable Installation

The cable shall be installed inside the 40mm diameter PLB HDPE pipe installed under this package along the route(s). Generally the cable shall be installed by compressed air blowing technique. However, for spans upto 150 meter, the Contractor can use pulling method for installation of OFC in HDPE pipe. If any temporary manhole or hand hole is required for installation of OFC, the same will be done by the Contractor without any additional cost implication. Adopting pulling method for installation of OFC for spans more than 150 meter, shall be subjected to approval of the Employer and shall be substantiated by proper justification. Contractor shall take into consideration the following guidelines, for installation of OFC approval by the Employer.

a. The Optical Fibre Cable Drums shall be handled with utmost care. The drum shall not be subjected to shocks by dropping etc. They shall not be normally rolled along the ground for long distance and when rolled, shall in the direction indicated by the arrow. The battens shall be removed only at the time of actual laying.
b. A blowing machine in association with an appropriate compressor shall be used for blowing.
c. Temporary blowing chambers (if required) shall be constructed and then backfilled after blowing operation is completed.
d. Locations along the route, which provide easy access points for blowing machine and compressor, shall be determined.
e. Before starting the cable blowing, PLB HDPE pipe shall be checked for obstacles or damage. Checking shall be done by using a proper sized mandrel.
f. Always blow downhill wherever possible.
g. Multiple blowing machines may be used in tandem if so required.
h. Care must be taken not to violate the minimum bending radius applicable for the fibre optic cable. Tension in the cable during laying shall not exceed tension limit of the OFC. Installation by pulling may be permitted by the Employer only in specific cases where installation by blowing is not feasible on specific approval from the Employer. In case pulling is used, the pulling speed shall be determined considering the site condition. While installing the cable, excess length of about 10 meters shall be stored at each joint location for each side. Excess length of 10 m shall be kept at one ends of a road crossing culvert crossing and 20 meters at one end of bridges. However, exact excess lengths and manhole locations shall be finalised during detailed engineering depending upon the site requirement.

As Built Drawings/details

The Contractor shall submit the as built drawings for the whole route indicating the route, depth of digging and manhole locations for easy maintenance of the installed system.

List of Drawings/documents required to be submitted for Employer's Approval

The Contractor shall ensure that the required drawings and documents are submitted well in time to avoid any delay in approval and project execution. The following minimum drawings and documents are required to be submitted by the Contractor for approval of the Employer:

a. The methods/procedures and the equipment/machines to be used for different types of trenchless digging techniques
b. Bill of quantities for various items as per contract
c. SAT Reports
d. As built drawings

20.52.6 Site Acceptance Testing (SAT)

The tests, checks, adjustments etc conducted by the Contractor prior to offering the equipment/material for SAT shall be called Pre-SAT activities. During installation the Contractor shall maintain proper record of measurements in approved format and shall be given to the Owner/Employer (along with As Built drawing of the routes) for cross checking during SAT.

SAT for Excavation, Backfilling, Installation of Pipes, Manholes.

The tests shall include but shall not be limited to the following:

a. Depth Check: One sample every 200 mtrs, Contractor shall prepare a sample pit at a location identified by the Employer. Depth of each item, warning tape, no. Of warning bricks (if applicable), pipes, cable etc. Shall be measured. Depth shall be as per technical specifications and shall correspond to recorded measurements.

b. Crossings: 10% of each type, visual inspection for checking conformance with drawings, thickness of Concrete, RCC Hume Pipe and GI pipe.

c. Manholes: As per technical specifications.

After inspection the Contractor shall backfill and carry out other restoration work at no additional cost to the Owner/Employer.

SAT for Underground Fibre Optic Cable

SAT for optical fibre cable shall be carried out link by link. Prior to installation, every fibre optic cable segment shall be tested for continuity and attenuation and measurements shall be recorded. Test requirements are as per table 2-7. Any discontinuity or attenuation beyond permissible limits in any of the fibres has to be recorded and brought to the notice of Employer. Upon completion of a continuous cable path, all fibres within the cable path shall be demonstrated for acceptance of the cable path. Test requirements are indicated in table 2-9 and in no case losses attributed due to other factors viz. Extra splice, kinks, will be acceptable to the limit determine by the following formula:

Max attenuation @ 1550 nm: 0.21dB/km + 0.05dB x total no of splices + 0.5dB x connector

Max attenuation @ 1310nm: 0.35dB/km + 0.05dB x total no of Splices + 0.5dB x connector

Any increase in attenuation or step discontinuity in attenuation shall not be acceptable and shall constitute a cable failure during installation. The Contractor shall have to either replace the concerned cable span at its own cost or provide additional splicing, joint box and manholes required to rectify the fault at its own cost. The fibre attenuation shall be tested again after replacement or rectification of fault. In case it is found that the splices are bad (loss is unacceptable as per approved test procedures), the Contractor shall have to do re-splicing and provide new Joint Box wherever required at no additional cost to the Owner/Employer. After re-splicing the end to end testing shall be repeated. The splice testing requirements are indicated in table below.

Table 6: Fibre Optic Cable Pre-Installation Testing

Item	Description

1	Physical Inspection of the cable assembly for damage
2	Optical fibre continuity and fibre attenuation with OTDR at 1550 nm

Table 7 : Fibre Optic Cable Splice Testing

Item	Description
1	Per splice attenuation with OTDR (bi-directional average) at 1550 nm
2	Physical inspection of Joint Box for proper fibre routing techniques
3	Physical inspection of sealing techniques, weatherproofing, etc

Table 8: Fibre Optic Cable Commissioning Testing

Item	Description
1	Fibre continuity and link attenuation (bi-directional) for each fibre at 1310 &1550 nm by OTDR
2	Fibre continuity and link attenuation (bi-directional) for each fibre at 1310 &1550 nm by Power Meter & Laser Source
3	Average splice loss (bi-directional) for each splices and average splice loss for the link by OTDR at 1550 nm.

SAT for PLB HDPE pipe

For PLB HDPE pipes, duct integrity tests shall be carried out as described below. The **Duct cleaning (Sponge test)** test shall be carried out on all the ducts before blowing/pulling of the cable between two consecutive manholes on the PLB HDPE pipes.

Duct cleaning (Sponge test)

Compressed air should be blown through the PLB HDPE pipe in order to remove dirt and water, if any, with the help of suitable Air Compressor. A short blast of air about 2-3 Bar shall be blown through the PLB HDPE pipe for about 2 minutes. Sponge shall be blown through the duct to thoroughly clean the duct from inside.

Crush and deformity test

Place a shuttle of length <15cm and O.D. 80% of the inner diameter of the offered PLB HDPE pipe. Connect the compressor pipe with a suitable flexible wire grip at the other end to catch the shuttle and start blowing operation to the pipe and check if shuttle reaches at the other end. If shuttle gets stuck the Contractor shall adopt suitable arrangement at site to locate the deformity/damage in the HDPE pipe, repair the pipe and ensure end-to-end continuity of the duct in sound condition.

20.52.7 Documentation

Apart from survey reports as mentioned above, the Contractor will submit the following documents after completion of the job and acceptance by the Employer:

(a) As built drawing of the route indicating the distance from road centre, OFC drum length, location of other utilities, link Q, OFC loop length, name of the road, sections and positions of PLB HDPE pipes, couplers, warning bricks/stone, manholes, G.I. pipes, RCC pipes, joint box, conduits, bends, trays, optical fibre cable loop lengths in manholes etc.

(b) Depth of PLB HDPE pipe in various sections of the route executed through open trenching.

(c) Sections of trenching digging executed through various methods.

(d) Specific deviation w.r.t. the installation and supply items, if any, from the technical specification. If there is no deviation, either explicit or implicit, the Contractor will provide a certification to this effect.

(e) Without submission of the above documentations, the Site Acceptance Testing of various items as described above will be deemed to be incomplete.

20.52.8 Miscellaneous Jobs

In order to provide end-to-end connectivity, it may be required to execute some miscellaneous jobs as detailed below.

Routing of Cables inside building.

In order to route the OFC (Optical Fibre Cable) from the underground trench to the control room building it is necessary to install the cable on walls inside PLB HDPE pipe over the existing cable tray/raceways inside the building.

Installation of PLB HDPE pipe on wall

The PLB HDPE pipe may be required to be installed on the wall using steel or G.I clamps. The contractor will provide the required clamps and other consumables sufficient for such installation. The contractor will take care of aesthetics while installation. The OFC will be pulled through the PLB HDPE pipe with due care as described in relevant Para of this specification.

20.52.9 INSPECTION & TESTING

Type Testing

Bidder shall offer the type tested product meeting the requirement of technical specifications.

Factory Acceptance Tests

Factory acceptance tests shall be conducted on randomly selected final assemblies of all equipment to be supplied. Visual inspection shall be carried out on 100% basis for all the equipment/items offered. Factory acceptance testing shall be carried out on Underground fibre optic cable, Joint box, PLB HDPE pipe etc.

20.52.10 System Maintenance

The one year period commencing immediately after the operational acceptance is called the Defect liability Period/warranty period. Operational Acceptance shall be given on successful completion of SAT. During this period, the Contractor shall replace or repair all defective parts. The one year period commencing immediately after the operational acceptance is called the Warrantee Period/Defect Liability Period. During the Warranty Period/Defect Liability Period, the Contractor shall guarantee that there shall be minimum outage of the supplied system. During this period, the Contractor shall replace or repair all defective parts and shall have prime responsibility for maintaining an operational system.

20.52.11 Documentation

The documentation provided shall include the following:

(a) Detailed list of the deliverables

(b) Description of the products

(c) Technical particulars

(d) Installation manuals

(e) Maintenance manuals

(f) Quality assurance manuals, Manufacturing Quality Plan (MQP) & Field Quality

20.53 SPECIFIC TECHNICAL PARTICULARS FOR 33 KV XLPE CABLE

Sl.No.	Particulars	Details
1	Description of Cable	ARMOURING: ARMOURED CORE MATERIAL: COPPER INSULATION: XLPE NOMINAL AREA: As per BoQ. NO.OF CORE: Single Core SHEATHING MATERIAL: EXTRUDED PVC, INNER & OUTER VOLTAGE GRADE: 33KV
2	Highest system voltage	36 KV
3	Voltage Grade	19/ 33KV
4	Earthing System	Effectively earthed
5	Frequency	50 Hz
6	Size of Cable	As per BoQ
	No. of Core	1C
7	Rated Power Frequency Withstand Voltage (1 min)	70 KV (rms)
8	Impulse withstand BIL (1.2/ 50/ micro Sec) Line to earth	±170 kVp
9	Rated short time withstand current	31.5 KA (rms) for 1 sec
10	Rated peak withstand current (1 sec)	78.75 KA
11	No of phase per Ckt	3
12	Maxm.Conductor temp	90 degree C at maxm. continuous current
13	Maxm. Permissible short circuit Temperature	250 degree C for one second
14	End Sealing	H.S. Caps
15	**CABLE DETAILS : CONDUCTORS**	
i	Conductor material	Plain un-tinned annealed copper
ii	Conductor Shape	Compacted circular.

iii	Conductor Screen	Extruded, Cross-linked, semi conducting compound of suitable thickness. Semi conducting separator tapes with 50% overlap to be applied between conductor and conductor screen.
iv	Resistivity of the semiconducting screen	Maximum 1000 ohm-meter
16	**INSULATION**	
i	Insulation material	XLPE
ii	Insulation thickness	8.8 mm (Nominal thickness)
iii	specified insulation resistance at 90^0C	$1x10^{12}$ ohm cm
iv	Insulation Screen: Type & Material	Freely strippable (with heat) type extruded non-metallic semi conducting compound followed by copper metallic tape with minimum 25 % overlapping.
16	Resistivity of the semiconducting compound	Max 500 Ohm-meter
17	Longitudinal water barrier Material	Layer of semiconducting tape with suitable water swellable absorbent with 50% overlap.
18	Overall sheath	Extruded black HDPE (TypeST7) with anti termite and anti rodent treatment.
19	Coating of outer sheath	A hard baked layer of graphite or semi conducting layer shall be applied over the outer sheath as outer electrode for testing the sheath.
	Armouring	Armoured
20	**TESTS**	
i	Type Test	All tests as per specifications IEC Standards.
ii	Routine Test	All tests as per specifications IEC Standards.
iii	Acceptance Test	All tests as per specifications IEC Standards.
iv	Whether test will be witnessed by purchaser or his representative	Yes. Acceptance test will be witnessed.
21	Bending Radius	The minimum bending radius of XLPE insulated cables as follows:

		Cable: Bending radius Single Core: 25xD D – diameter of overall conductor.

20.54 SPECIFIC TECHNICAL PARTICULARS FOR 66KV, 132 KV & 220KV XLPE CABLE

Sl.No.	ITEMS	PARTICULARS
1	Description of Cable	Stranded single core compacted copper core screening by a layer of semi conducting tape followed by a layer of semiconducting compound as conductor screen, XLPE insulation, insulation screening with semiconducting compound extruded directly over the insulation, (semiconducting conductor screen, XLPE insulation, semiconducting insulation screen-all in one triple extrusion process), longitudinal sealing by a layer of water swellable semiconducting non woven tape over insulation screen, followed by radial sealing (**metal sheath of Corrugated Aluminum**),and overall extruded black HDPE Sheathed (TypeST7).
2	Highest system voltage	72.5KV 145KV 245KV
3	Voltage Grade	36/66KV 76/132KV 127/220KV
4	Voltage variation	+10% and -12.5%
5	Frequency	50 Hz
6	Frequency variation	±3%
7	Power frequency withstand voltage	90KV rms for 30 minutes 190 KV rms for 30 minutes 318KV for 30 minutes
8	Lightning impulse withstand voltage	±325KVpeak 650KVpeak 1050peak
10	No of phase per Ckt	3
11	Earthing system	Effectively earthed
12	Size of Cable	As per BoQ
13	Max. in Conductor Temp.	90ºC at maximum continuous current.
14	Fault level	31.5KA for 3 second 40Ka for 3 second

		50KA for 3 second (considering parallel path of lead sheath and screen copper for metallic screen)
15	Maximum permissible short ckt temperature.	250ºC for one second.
16	**CABLE DETAILS : CONDUCTORS**	
16.1	Conductor material	Plain un-tinned annealed copper.
16.2	Conductor Shape	Compacted circular.
16.3	Conductor Screen	Extruded, Cross-linked, semi conducting compound of suitable thickness. Semi conducting separator tapes with 50% overlap to be applied between conductor and conductor screen.
16.4	Resistivity of the semiconducting screen	Maximum 1000 ohm-meter
16.5	Insulation	
	a)material	XLPE
	b)specified insulation resistance at 90^0C	$1x10^{12}$ ohm cm
16.6	Insulation Screen: Type & Material	Extruded semi conducting compound.
16.7	Resistivity of the semiconducting compound	Max 500 Ohm-meter
16.8	Longitudinal water barrier Material	Layer of semiconducting tape with suitable water swellable absorbent with 50% overlap.
16.9	Radial moisture barrier Material	Seamless or seam welded Corrugated Aluminum sheath with anti-corrosive material.
16.10	Overall sheath	Extruded black HDPE (TypeST7) with anti termite and anti rodent treatment.
16.11	Coating of outer sheath	A hard baked layer of graphite or semi conducting layer shall be applied over the outer sheath as outer electrode for testing the sheath.
17.	Approximate Length of cable in a drum	500 metres with a tolerance range of ±5% or as per requirement.
18	Bending Radius	The minimum bending radius of XLPE insulated cables as follows: Cable: Bending radius Single Core: 25xD D – diameter of overall conductor.
19	**TESTS** Applicable standards	IEC60840 IEC62067
19.1	Type Test a)whether previous test reports will be sufficient	All tests as per specifications IEC Standards Yes, if done on identical cable. No, if done on identical cable.

	b)whether sample to be Type tested against this order.	
19.2	Routine Test	All tests as per specifications IEC Standards.
19.3	Acceptance Test	All tests as per specifications IEC Standards.
19.4	Whether test will be witnessed by purchaser or his representative	Yes. Acceptance test will be witnessed.
20	**INSTALLATION, TERMINATION AND JOINTS**	
21	Ambient temperature Ground temperature Thermal resistivity of soil	45^0C 30^0C 150^0C cm/Km
22	Laying Configuration	Trefoil formation.
23	Depth	1.5 m below ground level.
24	Termination	
25	Type	**AS per requirement**
26	Joints Required	**No**
27	Earth Link Boxes Required	**Yes. In both end and at joints as per cable bonding system**
28	Surge Suppressor Required	**Yes**
29	Type Bonding ‘	**Single end bonding/ cross bonding**

CHAPTER 21: TECHNICAL SPECIFICATION FOR SHUNT REACTOR (UPTO 400kV), NEUTRAL GROUNDING REACTOR AND SURGE ARRESTER

21.1 GENERAL

This specification covers design, engineering, manufacture, testing, delivery at site including all materials, accessories, spares, unloading, handling, proper storage at site, erection, testing and commissioning of the equipment specified.

The design of 3 phase 50, 63, 80, 125 MVAr reactor bank shall be suitable for bay width of the substation/s.

If the reactor is intended to be used as Line reactor, then NGR and SA shall be supplied as per technical specification. However, if it is intended to be used as Bay reactor, then NGR and SA shall not be supplied.

Each reactor shall be supplied with *(i) One number or Oil Storage tank, (ii) 3 nos. of oil sampling bottles, (iii) On line DGA, (iv) Fiber optic sensors, (v) Nitrogen Injection System for Protection against the Fire & Explosion etc.*

21.2 TYPE OF REACTOR

The shunt reactor shall be of either gapped core type or magnetically shielded air core type (shell type) construction. The impedance ratio (X0/X1) specified shall be achieved by any one of the following methods:

- Adopting single phase construction in separate tanks.
- Adopting 5 limb core construction, for 3-Phase

In case of coreless construction following requirements are stipulated.

- A magnetic shield shall be provided around the coreless coils.
- Non-magnetic material sheet shall form the central core to minimize the vibrations.

The neutral grounding reactors are required for grounding of the neutral point of shunt reactors to limit the secondary arc current and the recovery voltage to a minimum value.

21.3 TRANSPORTATION

21.3.1 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 Reactor for all the stages from the manufacturer's work to site.

21.3.2 The contractor shall carry out the route survey along with the transporter and finalise the detail methodology for transportation of reactor and based on route survey, any modification/ extension/ improvement to existing road, bridges, culverts etc. if required, shall be in the scope of the bidder.

21.3.3 The inland transportation of the reactor unit shall be on trailer equipped with GPS system for tracking the location of Reactor at all times during transportation from manufacturer works to designated site. The contractor shall intimate to Employer about the details of transporter engaged for transportation of the Reactor. The requisite details for tracking the Reactor during transit shall be provided to Employer. Requirement of Hydraulic trailer is envisaged for 400kV Shunt Reactor.

21.3.4 All metal blanking plates and covers, which are specifically required to transport the reactor, shall be considered part of the reactor and handed over to the Employer after completion of the erection. Bill of quantity of these items shall be included in the relevant drawing/document.

21.3.5 The Contractor shall dispatch the reactor filled with dry air at positive pressure. The necessary arrangement shall be ensured by the contractor to take care of pressure drop of dry air during transit and storage till completion of oil filling during erection. A dry air pressure testing valve with necessary pressure gauge and adaptor valve shall be provided. Generally, the duration of the storage of reactor at site with dry air, shall preferably be limited to three months, after which the Reactor shall be processed as per the recommendation of manufacturer if not filled with oil. The dry air cylinder(s) provided to maintain positive pressure can be taken back by the contractor after oil filling.

21.3.6 In case turret, having insulation assembly, is transported separately then positive dry air pressure shall be ensured.

21.3.7 Reactor shall also be fitted with Electronic impact recorders (on returnable basis) atleast 2 numbers for 400kV Class Reactor and 1 number for below 400kV class Reactors during transportation to measure the magnitude and duration of the impact in all three directions. The mounting location of impact recorder shall be finalised during detailed engineering. The acceptance criteria and limits of impact, which can be withstood by the equipment during transportation and handling in all three directions, shall not exceed “3g” for 50mSec (20Hz) or as per contractor standard, whichever is lower.

21.4 PERFORMANCE

21.4.1 Shunt Reactors will be connected to the transmission system for reactive compensation and shall be capable of controlling the dynamic over voltage occurring in the system due to load rejection.

21.4.2 The reactors shall be designed for switching surge overvoltage of 2.5 p.u. and temporary overvoltage of the order of 2.3 p.u. for few cycles followed by power frequency overvoltage upto 1.5 p.u. The reactor must withstand the stress due to above transient dynamic conditions which may cause additional current flow as a result of changed saturation characteristics/slope beyond 1.5 p.u. voltage.

21.4.3 Shunt Reactors of 420kV Class shall be capable of operating continuously at a voltage 5% higher than their rated voltage without exceeding winding hot spot temperature 140 Deg Celsius. Maximum ambient temperature shall be considered as 50 Deg C.

21.4.4 Shunt Reactors of 245kV Class and below shall be capable of operating continuously at a voltage 10% higher than their rated voltage without exceeding winding hot spot temperature 140 Deg Celsius. Maximum ambient temperature shall be considered as 50 Deg C.

21.4.5 The reactor shall be designed to withstand the following over-voltages repeatedly without risk of failure (w.r.t. Hotspot temperature & core saturation):

21.4.6 1.05 Ur for continuous (for 420kV Class Reactor)
21.4.7 1.10 Ur for continuous (for below 420kV Class Reactor)
21.4.8 1.25 Ur for 1 minute
21.4.9 1.50 Ur for 5 seconds
21.4.10 The winding hot spots shall be calculated using the maximum localized losses, insulation thickness at the maximum loss positions, and the oil flow patterns in the winding. The oil temperature rise in the windings shall be used to determine hot spots rather than the bulk top oil temperature. The hot spot for all leads shall be calculated and it shall not exceed the calculated hot spot of the windings.

21.4.11 The hot spot temperatures and surface temperatures in the magnetic circuit (core) shall be calculated with maximum allowed 125 deg C and 120 deg C respectively under over voltage conditions specified above.

21.4.12 Also, the most onerous temperature of any part of the core and its supporting structure in contact with insulation or non-metal material shall not exceed the safe operating temperature of that material. Adequate temperature margins shall be provided to maintain long life expectancy of these materials.

21.4.13 Tank hotspot temperature under over voltage condition specified above shall not exceed 130 Deg C considering maximum ambient temperature as 50 Deg C.

21.4.14 The magnetic circuit will be designed such that the reactor is linear upto voltage specified at Annexure – A.

21.5 RADIO INTERFERENCE AND NOISE LEVEL

21.6 MEASURABLE DEFECTS

The following shall constitute as Measureable Defects for the purpose of DefectLiabilities as per relevant clauses of GCC / SCC of the bidding document:

a) Repair, inside the Reactor either at site or at factory is carried out after commissioning.

b) The concentration of any fault gas is more than values of condition-1 indicated in clause no 6.5 of IEEE-C57.104-2008, which are given below:

H2	CH4	C2H2	C2H4	C2H6	CO	CO2	TDCG
100	**120**	**1**	**50**	**65**	**350**	**2500**	**720**

c) The winding Tan delta goes beyond 0.005 or increase more than 0.001 withina year w.r.t. pre-commissioning values. No temperature correction factor shall be applicable for tan delta

a) The moisture content goes above 12 ppm at any temperature during operation.

21.5.1 The reactor shall be designed with particular attention to the suppression of harmonic voltage, especially the third and fifth so as to minimise interference with communication circuit.

21.5.2 The noise level of reactor, when energised at rated voltage and frequency shall not exceed the values specified at **Annexure-A** measured under standard conditions as defined in IEC.

21.7 GUARANTEED LOSSES AND PENALTY

MAXIMUM LOSSES: While the Bidders may offer their own design, it may be noted that the reactor losses at 75 deg. C. at rated output, rated Voltage and rated frequency should not exceed the following maximum limits in accordance with **Standard Fixed Losses for Transformers and Shunt Reactors as per Central Electricity Authority (CEA) letter no. CEA/PSE&TD/218/3056-4028 dated 01.03.19:**

RATING (MVAR)	VOLTAGE RATING (kV)	PHASE	LOAD LOSS (kW)	I²R (kW)	(CORE+STRAY+EDDY) (kW)	%
125	420	3-Phase	160	90	70	44
80	420	3-Phase	115	65	50	43
63	420	3-Phase	100	57	43	43
50	420	3-Phase	85	45	40	47

The total losses in kilowatts (including BIS tolerance) at rated output, rated voltage and rated frequency at 75°C shall be guaranteed by the bidder. It may be noted that the losses of the reactor shall not exceed during final testing of the reactor, if the same exceeds from the maximum ceiling limit of reactor losses as detailed above then the reactor shall not be accepted.
One **400 KV, 50/63/80/125 MVAR three phase shunt reactor** of each manufacturer (if there are more than one manufacturer) shall be subject to heat run test (Temperature rise test).

21.8 DESIGN REVIEW

21.8.1 The reactor 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 w.r.t. thermal, mechanical, dielectric and electrical stress etc. shall be maintained during design, selection of raw material, manufacturing process etc. in order to achieve long life of reactor with least maintenance.

21.8.2 Design reviews shall be conducted by Employer or by an appointed consultant during the procurement process for Reactors; however the entire responsibility of design shall be with the manufacturer. Employer may also visit the manufacturers works to inspect design, manufacturing and test facilities.

21.8.3 The design review will commence after placement of award with the successful bidder and shall be finalised before commencement of manufacturing activity. These design reviews shall be carried out in detail to the specific design with reference of the reactor under the scope of this specification. It shall be conducted generally following the “Guidelines for conducting design reviews for power transformers working group A2.36 Task Force 2” (Replaces TB 204).

21.8.4 The manufacturer shall provide all necessary information and calculations to demonstrate that the reactor meets the requirements for mechanical strength and durability due to inrush current. The latest recommendations of IEC and Cigre SC 12 shall be applied for short circuit withstand evaluation.

21.8.5 The manufacturer will be required to demonstrate the use of adequate safety margins for thermal, mechanical, dielectric and vibration etc. in design to take into account the uncertainties of his design and manufacturing processes. The scope of such design review shall include but not limited to the requirement as mentioned at Annexure – E.

21.8.6 The validity of Type tests of Reactor shall be 5 years as on the date of NOA, provided that offered reactor is of same design as that of type tested reactor and active materials like – CRGO, copper conductor and insulation material are of same or better grade with respect to type tested unit. Failing which, type testing of reactor shall be carried out by the contractor at his own cost. Further, type test report of reactor from the same manufacturing plant shall only be acceptable.

21.9 CONSTRUCTION DETAILS

The construction details and features of each Shunt Reactor shall be in accordancewith the requirement stated hereunder.

21.9.1 TANK

21.9.1.1 Tank shall be fabricated from tested quality low carbon steel of adequate thickness. Unless otherwise approved, metal plate, bar and sections for fabrication shall comply with BS-4360 / IS 2062.

21.9.1.2 All seams and those joints not required to be opened at site, shall be factory welded, and wherever possible they shall be double welded. Welding shall conform to BS-

21.9.1.3 5135/IS 9595. After fabrication 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/IS 10801.

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

21.9.1.5 The tank shall be of proven design either bell type with bolted /welded joint or conventional type with welded / bolted top cover. Bell type tank shall be provided with joint at about 500 mm above the bottom of the tank. The welded joint shall be provided with flanges suitable for repeated welding. The joint shall be provided with a suitable gasket to prevent weld spatter inside the tank. Proper tank shielding shall be done to prevent excessive temperature rise at the joint.

21.9.1.6 Tank shall be provided with:

a. Lifting lugs: Four symmetrically placed lifting lugs shall be provided so that it will be possible to lift the complete Reactor when filled with oil without structural damage to any part of the Reactor. The factor of safety at any one point shall not be less than 2.

b. A minimum of four jacking pads in accessible position to enable the Reactor 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 at least half of the total mass of the Reactor 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.
d. 04 nos. of Gate valves for UHF sensors for PD Measurements (applicable for 420kV Reactor only) at various locations. Location of valves shall be finalized during design review.

e. Suitable provisions of pockets for OTI, WTI & RTDs including two spare pockets.

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

21.9.1.8 The base of each tank shall be so designed that it shall be possible to move the complete Reactor unit by skidding in any direction without damage when using plates or rails.

21.9.2 TANK COVER

21.9.2.1 The tank cover shall be designed to prevent retention of 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.

21.9.2.2 At least two adequately sized inspection openings one at each end of the tank, shall be provided 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.

21.9.2.3 The tank cover shall be provided with pockets for oil and winding temperature indicators. The location of pockets shall be in the position where oil reaches maximum temperature. Further, it shall be possible to remove bulbs of OTI/WTI/RTD without lowering the oil in the tank. The thermometer shall be fitted with a captive screw to prevent the ingress of water.

21.9.2.4 Bushing turrets, covers of inspection openings, thermometer pockets etc. shall be designed to prevent ingress of water into or leakage of oil from the tank.

21.9.2.5 All bolted connections shall be fitted with weather proof, hot oil resistant, resilient gasket in between for complete oil tightness. If gasket is compressible, metallic stops/other suitable means shall be provided to prevent over-compression

21.9.2.6 Currents flowing in tank cover and bushing turrets - To allow for the effect of possible induced and capacitive surge current, the tank cover and bushing turret shall be fixed to the Reactor in such a way that good electrical contact is maintained around the perimeter of the tank and turrets.

21.9.2.7 The Reactor shall be provided with a 100 mm nominal diameter butterfly valve and bolted blanking plate, gasket and shall be fitted at the highest point of the Reactor for maintaining vacuum in the tank.

21.9.2.8 Gas venting - The reactor cover, and generally the internal spaces of the reactor and all pipe connections shall be designed so as to provide efficient venting of any gas in any part of the reactor to the Buchholz relay. The space created under inspection/manhole covers shall be filled with suitable material to avoid inadvertent gas pockets. The Covers shall be vented at least at both longitudinal ends. The design for gas venting shall take into accounts the slopes of the plinth (if any) on which the Reactor is being mounted.

21.9.3 GASKET FOR TANK & COVER

All gasketed joints shall be designed, manufactured and assembled to ensure long- term leak and maintenance free operation. All gasketed joints unless otherwise approved shall be of the O-ring and groove type. Groove provided to accommodate round nitrile rubber cord for rectangular openings shall be milled. The Gaskets in contact with oil shall be Nitrile rubber or any better approved quality.

The properties of all the above gaskets / O-Rings shall comply with the requirements of IS-11149. Gaskets and O-rings shall be replaced every time whenever the joints are opened.

21.9.4 ROLLER ASSEMBLY & ANTI EARTHQUAKE CLAMPING DEVICE

The Reactor shall be placed directly on concrete plinth foundation. To facilitate the movement of reactor to its foundation over rail track, bi-directional flanged rollers shall be provided. It shall be suitable for fixing to the under carriage of Reactor. The rail track gauge shall be 1676 mm. Two rails shall be provided as per the drawing mentioned at **Annexure-D.**

Scope shall include supply of complete one set of rollers assembly for movement of reactor over rail track for each substation. To prevent Reactor movement during earthquake, suitable clamping devices shall be provided for fixing the Reactor to thefoundation.

21.9.5 CONSERVATOR

21.9.5.1 Conservator shall have air cell type constant oil pressure system to prevent oxidation and contamination of oil due to contact with moisture. Conservator shall be fitted with magnetic oil level gauge with potential free high and low oil level alarm contacts and prismatic oil level gauge.

21.9.5.2 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 reactor and cooling equipment from minimum ambient temperature to top oil temperature of 110 deg C. The capacity of the conservator tank shall be such that the reactor shall be able to carry the specified overload without overflowing of oil.

21.9.5.3 The conservator shall be fitted with 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 as applicable.

21.9.5.4 Conservator shall be positioned so as not to obstruct any electrical connection to Reactor.

21.9.5.5 The connection of air cell to the top of the conservator is by air proof seal preventing entrance of air into the conservator. The main conservator tank shall be stencilled on its underside with the words “Caution: Air cell fitted”. Lettering of at least 150 mm size shall be used in such a way to ensure clear legibility from ground level when the Reactor is fully installed. To prevent oil filling into the air cell, the oil filling aperture shall be clearly marked. The Reactor rating and diagram plate shall bear a warning statement that the “Conservator is fitted with an air cell”.

21.9.5.6 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 in the conservator is likely to raise up to 110OC during operation. As such air cell used shall be suitable for operating continuously at this temperature.

21.9.5.7 The reactor 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, and the recommended replacement intervals.

21.9.5.8 The conservator tank and piping shall be designed for complete vacuum / filling of the main tank and conservator tank. Provision must be made for equalising the pressure in the conservator tank and the air cell during vacuum / filling operations to prevent rupturing of the air cell.

21.9.5.9 The contractor shall furnish the leakage rates of the rubber bag/ air cell for oxygen and moisture. It is preferred that the leakage rate for oxygen from the air cell into the oil will be low enough that the oil will not become saturated with oxygen before 10 years. Air cells with well proven long life characteristics shall be preferred.

21.9.6 PIPING WORKS FOR CONSERVATOR

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

21.9.6.2 The feed pipe to the Reactor tank shall enter the reactor cover plate at its highest point and shall be straight for a distance not less than five times its internal diameter on the reactor 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 degrees. The feed pipe diameter for the main conservator shall be not less than 80 mm for reactor. Gas-venting pipes shall be connected to the final rising pipe between the reactor and Buchholz relay as near as possible in axial direction and preferably not less than five times pipe diameters from the Buchholz relay.

21.9.6.3 A double flange valve of preferably 50 mm size shall be provided to fully drain the oil from the main tank conservator.

21.9.6.4 Pipe work shall neither obstruct the removal of the opening of inspection or manhole covers.

21.9.7 DEHYDRATING SILICAGEL FILTER BREATHER

Conservator shall be fitted with a dehydrating silicagel filter breather. 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 having a mass less than 10 kg may be supported by the connecting pipe, whereas units of 10 kg and above shall be supported independent of the connecting pipe. Connecting pipes shall be securely cleated to the reactor, or other structure supplied by the contractor, in such a manner so as to eliminate undesirable vibration and noise. In the case where a breather of less than 10 kg is supported by the pipe, there shall be a cleat directly above the breather flange. It shall be so designed that:

a) Passage of air is through silicagel.
b) Silicagel is isolated from atmosphere by an oil seal.
c) Moisture absorption indicated by a change in colour of the crystals.
d) Breather is mounted approximately 1200 mm above rail top level.
e) To minimise the ingress of moisture three breathers (of identical size) shall be connected in series for main tank conservator. Contractor shall provide flexible connection pipes to be used during replacement of any silicagel breather.
f) Two breathers (each of 2.5 litres minimum volume) shall be connected in series for NGR tank conservator

21.9.8 PRESSURE RELIEF DEVICE

Adequate number of pressure relief devices (at least 2 numbers) shall be provided at suitable locations preferably close to bushing turret/ cover. These shall have opening diameter of at least 100 mm for rapid release of any pressure that may be generated in the tank and which may result in damage to equipment. The device shall maintain its oil tightness under static oil pressure equal to the static operating head of oil plus 20 kPa. The device shall operate and attain its full opening in not more than 2.5 ms when subject to an internal pressure impulse equal to static operating head of oil plus 50 kPa. It shall be capable of withstanding full internal vacuum at mean sea level. It shall be mounted directly on the tank. Suitable canopy shall be provided to prevent ingress of rain water. One set of potential free contacts (**with plug & socket type arrangement)** per device shall be provided for tripping. Following routine tests shallbe conducted on PRD:

a) Air pressure test
b) Liquid pressure test
c) Leakage test
d) Contact operation test
e) Dielectric test on contact terminals

21.9.9 SUDDEN PRESSURE RELAY

One number of Sudden Pressure relay with alarm/trip contacts **(Terminal connection plug & socket type arrangement**) shall be provided on tank of reactor. Operating features and size shall be reviewed during design review. Suitable canopy shall be provided to prevent ingress of rain water. Pressurised water ingress test for Terminal Box (routine tests) shall be conducted on Sudden Pressure Relay

21.9.10 BUCHHOLZ RELAY

Two numbers double float, reed type Buchholz relay shall be provided in series of the connecting pipe between the oil conservator and the Reactor tank with minimum distance of five times pipe diameters between them. Any gas evolved in the Reactor shall be collected 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 tube shall be connected from the gas collector to a valve located about 1200 mm above ground level to facilitate sampling while the Reactor in service. Suitable canopy shall be provided to prevent ingress of rain water. Each device shall be provided with two potential free contacts **(Plug & socket type arrangement),** one for alarm / trip on gas accumulation and the other for tripping on sudden rise of pressure.

The Buchholz relay shall not operate during starting/ stopping of the Reactor oil circulation under any oil temperature conditions. The pipe or relay aperture baffles shall not be used to decrease the sensitivity of the relay. The relay shall not mal- operate for through fault conditions or be influenced by the magnetic fields around the Reactor during the external fault conditions. Pressurised water ingress test for Terminal Box (routine tests) shall be conducted on Buchholz relay.

21.9.11 OIL TEMPERATURE INDICATOR (OTI)

All Reactors shall be provided with a dial type thermometer of around 150 mm diameter for top oil temperature indication. It shall have adjustable, potential free alarm and trip contacts besides that required for control of cooling equipment if any. A temperature sensing element suitably located in a pocket on top oil shall be provided. 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 deg C. Accuracy of OTI shall be ± 3.0 deg C or better for a temperature of 100 deg C. The setting of alarm and tripping contacts shall be adjustable at site.

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

21.9.12 TEMPERATURE TRANSDUCER WITH PT100 SENSOR

RTD shall be provided with Pt100 temperature sensor having nominal resistance of 100 ohms at zero degree centigrade. The Pt100 temperature sensor shall have three wire ungrounded system. The calibration shall be as per IEC 60751-2 or equivalent. The Pt100 sensor may be placed in the pocket containing temperature sensing element. RTD shall include image coil, for OTI system and shall provide dual output 4-20mA for SCADA system. The transducer shall be installed in the Individual Marshalling Box. Any special cable required for shielding purpose, for connection between Pt100 temperature sensor and transducer, shall be in the scope of Contractor. 4-20mA signal shall be wired to Control & relay panel for further transfer data to SCADA through IEC 61850 compliant communications.

21.9.13 WINDING TEMPERATURE INDICATOR (WTI)

A device for measuring the hot spot temperature of each winding (HV, IV and LV) shall be provided. All Reactors shall be provided with 150 mm dial type thermometer for winding temperature indication and shall have adjustable potential free alarm and trip contacts besides that required for control of cooling equipment if any. WTI shall have Temperature sensing element, Image coil and Auxiliary CTs, if required to match the image coil, shall be mounted in the cooler control cabinet. Temperature indicator dials shall have linear gradations to clearly read at least every 2 deg C. Accuracy of WTI shall be □ 3.0 deg C or better for a temperature of 100 deg C. The setting of alarm and tripping contacts shall be adjustable at site. For alarm & trip settings refer EMPLOYER Pre-Commissioning.
In addition to the above, the following accessories shall be provided for remote indication of oil temperature:

21.9.14 TEMPERATURE TRANSDUCER WITH PT100 SENSOR FOR EACH WINDING

RTD shall be provided with Pt100 temperature sensor having nominal resistance of 100 ohms at zero degree centigrade. The Pt100 temperature sensor shall have three wire ungrounded system. The calibration shall be as per IEC 60751-2 or equivalent. The Pt100 sensor may be placed in the pocket containing temperature sensing element. RTD shall include image coil, Auxiliary CTs, if required to match the image coil, for WTI system and shall provide dual output 4-20mA for SCADA system. The transducer, Auxiliary CT shall be installed in the Individual Marshalling Box. Any special cable required for shielding purpose, for connection between Pt100 temperature sensor and transducer, shall be in the scope of Contractor. 4-20mA signal shall be wired to Control & relay panel for further transfer data to SCADA through IEC 61850 compliant communications.

The temperature indicators (OTI & WTI) shall be so mounted that the dials are about 1200 mm from ground level. Glazed door of suitable size shall be provided for convenience of reading.

21.9.15 OPTICAL SENSORS & MEASURING UNIT

8 numbers optical temperature sensors shall be fitted on each unit. The optical sensors measuring system shall be of direct measurement non-calibrating type. All the sensors shall be brought out to separate optical sensor box or in individual marshalling box mounted on reactor tank or ground mounted to facilitate measurement of temperature during service life on each unit.

In order to facilitate measurement of temperature from the optical sensors, temperature-measuring unit/system having at least 8 channels shall be mounted inside the separate optical sensor box or marshalling box for each reactor unit. The measuring unit shall be capable to retain temperature data for at least 30 days with facility to download these data.

Temperature measuring unit/system shall be suitable for satisfactory operation with ambient conditions and IEC 61850 compliant to interface with Employer’s SCADA system through FO port. Location of optical temperature sensors inside the reactor shall be decided during design review.

The installation and commissioning at site shall be done under the supervision of OEM representative or OEM certified representative.

21.9.16 EARTHING TERMINALS

21.9.16.1 Two (2) earthing pads (each complete with two (2) nos. holes, M16 bolts, plain and spring washers) suitable for connection to 75 x 12 mm galvanised steel grounding flat shall be provided each at position close to earth of the two (2) diagonally opposite bottom corners of the tank.

21.9.16.2 Two earthing terminals suitable for connection to 75 x 12 mm galvanised steel flat shall also be provided on each individual/common marshalling box and any other equipment mounted separately. For the tank-mounted equipment like online drying/ Online DGA/etc double earthing shall be provided through the tank for which provision shall be made on the tank and connected through two flexible insulated copper link.

21.9.16.3 To allow for the effect of possible induced and capacitive surge current, good electrical connection is maintained between the tank and turrets. Equi-potential flexible copper link of suitable size at least 4 Nos. for Tank mounted turret with tank and tank with cover and or Bell shall be provided. For other components like - pipes, conservator support etc connected to tank shall also be provided with equipotential flexible copper link.

21.9.16.4 Each reactor unit should have provision for earthing suitable for connection to grounding mat when Reactor is out of service for longer duration. For this purpose, neutral shall have provision for connection to ground by a brass/tinned copper grounding bar supported from the tank by using porcelain insulator. The end of the tinned/brass copper bar shall be brought to the bottom of the tank at a convenient point for making bolted connection to 75 X 12 mm GS flat connected to station grounding mat. The other end of the tinned/brass copper bar shall be connected to the neutral bushing through flexible conductor/jumper. HV Terminal shall also be earthed through neutral by flexible copper connection. Contractor shall provide suitable arrangement for the above.

21.9.17 CORE

21.9.17.1 The core shall be constructed from non-ageing, cold rolled grain oriented silicon steel laminations of conventional grade (as per BIS) / regular grade (as per IEC) or better. Indian transformer manufacturers shall use core material as per above specification with BIS certification.

21.9.17.2 The leg magnetic packets (cheeses) shall be made from state of the art low loss electrical steel CRGO (conventional/regular grade or better). The “Cheeses” shall be designed to minimize losses and equalize the distribution of flux in the legs.

21.9.17.3 The “cheeses” shall be bonded using high temperature epoxy resins to assure that they will remain bonded in service at the maximum temperatures that will occur in the magnetic circuit and for the full expected life. Vacuum impregnation is preferred. The contractor shall present data on the characteristics of the packets at the time of design review.

21.9.17.4 Material with high temperature withstand capability such as ceramic/ slate spacers shall be used to separate the packets. High temperature, mechanically stable material shall be used between the end packets and the top and bottom yokes. Special care shall be taken not to impede the cooling in these areas.

21.9.17.5 Means shall be provided to distribute the flux from the “cheeses” and the windings to the top and bottom yokes to prevent concentrations of flux with resulting high temperatures in the yokes.

21.9.17.6 The yokes shall be designed such that high temperatures resulting from unequal distribution of the flux in the yokes will not occur.

21.9.17.7 The spaces between “cheeses” will be designed so that high temperatures will not result due to fringing of flux at the oil gaps between them. The designer shall calculate the temperatures resulting from fringing.

21.9.17.8 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.

21.9.18 INTERNAL STRUCTURE DESIGN

21.9.18.1 The structural design shall be made so that pressure will be maintained to prevent loosening resulting from thermal expansion and contraction during all loading cycles.

21.9.18.2 The design shall be made in such a way that excessive vibration does not occur in the windings, structural supports of the windings and magnetic circuit and this will be subjected to design review.

21.9.18.3 The structure shall be designed to withstand the clamping and magnetic forces. The calculated magnetic forces will be furnished at the time of design review.

21.9.18.4 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.

21.9.19 EARTHING OF CORE AND CLAMPING STRUCTURE

21.9.19.1 If grounding of the core cheeses are required a separate strap shall be brought to a terminal located in a waterproof enclosure on the tank. Separate ground leads will be routed from the top and bottom yokes to separate terminals in the enclosure.

21.9.19.2 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 reactor. The removable links shall have adequate section to carry ground fault current. Separate identification name plate/labels shall be provided forthe 'Core' and 'Core clamp' on the tank cover.

21.9.19.3 Unless otherwise approved, no core earthing connection shall be of minimum size of 80 sq.mm copper with exception of the connections inserted between laminations which may be reduced to a cross-sectional area of 20 sq. mm tinned copper where they are clamped between the laminations.

21.9.19.4 Where the core laminations are divided into sections by insulating barriers or cooling ducts parallel to the plane of the laminations, tinned copper bridging strips shall be inserted to maintain electrical continuity between sections.

21.9.19.5 A drawing showing the details of the earthing design and connection shall be furnished during detailed engineering.

21.9.20 WINDINGS

21.9.20.1 The Contractor shall ensure that windings of all Reactors are made in dust proof and conditioned atmosphere.

21.9.20.2 The conductors shall be of electrolytic grade copper free from scales and burrs.

21.9.20.3 The insulation of Reactor windings and connections shall be free from insulating compounds which are liable to soften, ooze out, shrink or collapse and shall be non- catalytic and chemically inactive in Reactor oil during service.

21.9.20.4 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.

21.9.20.5 The coils would be made up, shaped and braced to provide for expansion and contraction due to temperature changes.

21.9.20.6 The conductor shall be transposed at sufficient intervals in order to minimize eddy currents and to equalise the distribution of currents and temperature along the winding.

21.9.20.7 The windings shall be designed to withstand the dielectric tests specified. The type of winding used shall be of time tested. An analysis shall be made of the transient voltage distribution in the windings, and the clearances used to withstand the various voltages. Margins shall be used in recognition of manufacturing tolerances and the fact that the system will not always be in the new factory condition.

21.9.20.8 The barrier insulation including spacers shall be made from high-density pre- compressed pressboard (1.1 gm/cc minimum for load bearing and 1 gm/cc minimum for non-load bearing) to minimize dimensional changes.

21.9.20.9 All spacers shall have rounded edges. Radially stepped spacers between winding diskswill not be accepted.

21.9.20.10 The conductor insulation shall be made from high-density (at least 0.75 gm/cc) paper having high mechanical strength. The characteristics for the paper will be reviewed at the time of design review.

21.9.20.11 An electrostatic shield, made from material that will withstand the mechanical forces, will be used to shield the high voltage windings from the magnetic circuit unless otherwise approved.

21.9.20.12 BRACING OF WINDINGS

All winding insulation shall be processed to ensure that there will be no detrimental shrinkage after assembly. All windings shall be pre-sized before being clamped. Windings shall be provided with clamping arrangements which will distribute the clamping forces evenly over the ends of the winding.

The bracing of the windings and connections shall be such that these parts shall safely withstand the cumulative effects of stresses which may occur during handling, transportation, installation and service including line-to–line and line-to–ground faults.

Full details of the winding clamping arrangements, and their adjustment in or out of the tank together with relevant drawings and values, shall be submitted during design review.

21.9.21 CURRENT CARRYING CONNECTIONS

The mating faces of bolted connections shall be appropriately finished and prepared for achieving good long lasting, electrically stable and effective contacts. All lugs for crimping shall be of the correct size for the conductors. Connections shall be carefully designed to limit hot spots due to circulating eddy currents.

21.9.22 WINDING TERMINATIONS INTO BUSHINGS

21.9.22.1 Winding termination interfaces with bushings shall be designed to allow for repeatable and safe connection under site conditions to ensure the integrity of the Reactor in service.

21.9.22.2 The winding–end termination, insulation system and transport fixings shall be so designed that the integrity of the insulation system generally remains intact during repeated work in this area.

21.9.22.3 Allowances shall be made on the winding ends for accommodating tolerances on the axial dimensions of the set of bushings and also for the fact that bushings may have to be rotated.

21.9.22.4 In particular, rotation or straining of insulated connections shall be avoided during the fastening of conductor pads (or other methods) on the winding ends onto the termination surfaces of the bushing.

21.9.22.5 Suitable inspection and access facilities into the tank in the bushing oil-end area shall be provided to minimize the possibility of creating faults during the installation of bushings.

21.10 PAINTING SYSTEM AND PROCEDURES

The typical painting details for reactor main tank, pipes, conservator tank, radiator, control cabinet/ marshalling box / oil storage tank etc. shall be as given in **Annexure –F**. The proposed paint system shall generally be similar or better than this. The quality of paint should be such that its colour does not fade during drying process and shall be able to withstand temperature up to 120 deg C.

21.11 UNUSED INHIBITED INSULATING OIL

The insulating oil shall be virgin high grade inhibited, conforming to IEC-60296 & all parameters specified at **Annexure – G**, while tested at supplier's premises. The contractor shall furnish test certificates from the supplier against the acceptance norms as mentioned at **Annexure – G**, prior to dispatch of oil from refinery to site. Under no circumstances, poor quality oil shall be filled into the Reactor and only thereafter brought the specified parameter by circulation within the Reactor. The Unused inhibited Insulating Oil parameters including parameters of oil used at manufacturer’s works, processed oil, oil after filtration and settling are attached at **Annexure – G**. The oil test results shall form part of equipment test report.

Sufficient quantity of oil necessary for maintaining required oil level in case of leakage in tank, radiators, conservator etc. till the completion of warranty period shall be supplied.

Inhibited oil used for first filling, testing and impregnation of active parts at manufacturer's works shall be of same type of oil (in line with IEC 60076-3) which shall be supplied at site and shall meet parameters as per specification.

21.11.1 PARTICLES IN THE OIL

The particle analysis shall be carried out in an oil sample taken after completion of the oil filtration at site. The procedure and interpretation shall be in accordance with the recommendation of CIGRE report WG-12.17 - “Effect of particles on transformer dielectric strength”.

21.11.2 MOISTURE CONTENT IN THE SOLID INSULATION

Dummy insulation test block (2 Nos.) shall be inserted in the active part of Reactor at factory and same shall be used to detect the volume of moisture content. Manufacturer to ensure that moisture content in the dummy insulation test block is less than 0.5% after drying process of solid insulation. Out of two dummy blocks, one block shall be used during manufacturing stage and another one shall be sent with Reactor at site. Before application of vacuum and oil filling, the 2nd dummy block shall be used for DP Test (Degree of polymerisation).

To review the moisture content in the active part insulation at site during erection, Dew Point method shall be applied.

21.12 OIL FILLING

21.12.1 Procedures for site drying, oil purification, oil filling etc shall be done as per Field Quality Plan (FQP). The duration of the vacuum treatment shall be demonstrated as adequate by means of water / dew point measurement with a cold trap or other suitable method. The vacuum shall be measured on the top of the Reactor tank and should be less than 1mbar.

21.12.2 Oil filling under vacuum at site shall be done with reactor oil at a temperature not exceeding 65°C. Vacuum shall not be broken until the Reactor is oil filled up to the Buchholz relay.

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

21.13 OIL TREATMENT PLANT

The Ultra High Vacuum type oil treatment plant (on returnable basis) of suitable capacity (**minimum 6000** litres per hour) shall be arranged by the contractor at his own cost for treatment of oil in EHV class Reactor in order to achieve properties of treated oil. The plant shall be capable of treatment of oil at rated capacity on single pass basis as follows:

i) Removal of moisture from 100 ppm to 3 ppm (max.)
ii) Removal of dissolved gas content from 10% by Vol. to 0.1% by vol.
iii) Improvement of dielectric strength break down voltage from 20 to 70 KV
iv) Vacuum level of degassing chamber not more than 0.15 torr/0.2 mbar at rated flow and at final stage. Machine shall have minimum of two degassing chambers and these should have sufficient surface areas to achieve the final parameters.
v) Filter shall be capable of removing particle size more than 0.5 micron in the filtered oil.
vi) Processing temperature shall be automatically controlled and have an adjustable range from 40□C to 80□C.

21.14 TRANSPORTATION OF OIL

The insulating oil for the Reactor shall be delivered at site generally not before 90 days from the date of commissioning, with prior information to the Employer, in view of risk involved in balk storage, pilferage and fire hazard. In case this oil is not filled in reactor due to delay in commissioning, same oil shall be used only after testing and ensuring that oil parameters are well within the specified limits.

Insulating oil shall be delivered to the site in returnable oil drums / flexi bag / tanker. The oil drums / flexi bag / tanker shall be taken back without any extra cost to Employer within generally 45 days after utilisation of oil but in any case, before contract closing. However, the spare oil shall be delivered in non-returnable drums.

21.15 BUSHINGS

21.15.1 Bushings shall be robust and designed for adequate cantilever strength to meet the requirement of seismic condition, substation layout and movement along with the spare Reactor with bushing erected and provided with proper support from onefoundation to another foundation within the substation area. The electrical and mechanical characteristics of bushings shall be in accordance with IEC: 60137/DIN 42530. All details of the bushing shall be submitted for approval and design review.

21.15.2 Bushing for voltage of 52 kV and above shall be RIP bushing with composite insulator. 36 kV bushing shall be solid porcelain or oil communicating type.

21.15.3 RIP type bushing shall be provided with tap for capacitance and tan delta test. Test taps relying on pressure contacts against the outer earth layer of the bushing is not acceptable.

21.15.4 Where current transformers are specified, the bushings shall be removable without disturbing the current transformers.

21.15.5 Bushings of identical rating shall be interchangeable to optimise the requirement of spares. Mounting dimensions of bushing shall be as per drawing mentioned at Annexure – D.

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

21.15.7 Polymer / composite insulator shall be seamless sheath of a silicone rubber compound. The housing & weather sheds should have silicon content of minimum 30% by weight. It should protect the bushing against environmental influences, external pollution and humidity. The interface between the housing and the core must be uniform and without voids. The strength of the bond shall be greater than the tearing strength of the polymer. The manufacturer shall follow non-destructive technique (N.D.T.) to check the quality of jointing of the housing interface with the core. The technique being followed with detailed procedure and sampling shall be finalized during finalization of MQP.

The weather sheds of the insulators shall be of alternate shed profile as per IEC 60815-
3. The weather sheds shall be vulcanized to the sheath (extrusion process) or moulded as part of the sheath (injection moulding process) and free from imperfections. The vulcanization for extrusion process shall be at high temperature and for injection moulding shall be at high temperature & high pressure. Any seams / burrs protruding axially along the insulator, resulting from the injection moulding process shall be removed completely without causing any damage to the housing. The track resistance of housing and shed material shall be class 1A4.5 according to IEC60587**.** The strength of the weather shed to sheath interface shall be greater than the tearing strength of the polymer. The composite insulator shall be capable of high pressure washing.

End fittings shall be free from cracks, seams, shrinks, air holes and rough edges. End fittings should be effectively, sealed to prevent moisture ingress, effectiveness of sealing system must be supported by test documents. All surfaces of the metal parts shall be perfectly smooth with the projecting points or irregularities which may cause corona. All load bearing surfaces shall be smooth and uniform so as to distribute the loading stresses uniformly.

The hollow silicone composite insulators shall comply with the requirements of the IEC publications IEC 61462 and the relevant parts of IEC 62217. The design of thecomposite insulators shall be tested and verified according to IEC 61462 (Type &Routine test)

21.15.8 Clamps and fittings shall be of hot dip galvanised/stainless steel.

21.15.9 Bushing turrets shall be provided with vent pipes, to route any gas collection through the Buchholz relay.

21.15.10 No arcing horns shall be provided on the bushings.

21.15.11 Bushing shall be specially packed to avoid any damage during transit and suitable for long storage, with non-returnable packing wooden boxes with hinged type cover. Without any gap between wooden planks. Packing Box opening cover with nails/screws type packing arrangement shall not be acceptable. In case of RIP bushing with polymer housing, Bushing oil end portion shall be fitted with metal housing with positive dry air pressure and a suitable pressure monitoring device shall be fitted on the metal housing during storage to avoid direct contact with moisture with epoxy. Alternatively, oil filled metal housing with suitable arrangement for taking care oil expansion due to temperature variations shall also be acceptable. Manufacturer shall submit drawing/ documents of packing for approval during detail engineering. Detail method for storage of bushing including accessories shall be brought out in the instruction manual.

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

21.15.13 Tan delta measurement at variable frequency (in the range of 20 Hz to 350 Hz) shall be carried out on each condenser type bushing (OIP & RIP) at Reactor manufacturing works as routine test before dispatch and the result shall be compared at site during commissioning to verify the healthiness of the bushing.

21.15.14 If the bushing Tan delta goes beyond 0.005 or increase is more than 0.001 within the warrantee period w.r.t. pre-commissioning values, the contractor shall arrange to replace the defective bushing by new one. No temperature correction factor shall be applicable for tan delta.

21.16 NEUTRAL FORMATION AND EARTHING ARRANGEMENT.

21.16.1 FOR 3-PHASE UNIT:

The neutral of the shunt reactor shall be brought out through neutral bushing. The Contractor shall provide Aluminium clamps & connectors suitable for conductor between neutral of the shunt reactor, surge arrester and the neutral grounding reactor (NGR) as applicable.

21.16.2 The neutral of shunt reactor shall be grounded either directly or through a neutral grounding reactor (NGR) as the case may be. The neutral terminal of Reactors and NGR 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.

21.17 COOLING EQUIPMENT

21.17.1 The reactor shall be designed for Oil Natural Air Natural Cooling (ONAN)

21.17.2 The radiator bank of the shunt reactor shall be either tank mounted or separately mounted based on manufacturer’s standard practice. For neutral grounding reactor, the radiator, if required, may be tank mounted.

21.17.3 Design of cooling system shall satisfy the performance requirements. The radiator shall be of sheet steel in accordance with IS 513 and minimum thickness 1 mm. Each radiator bank shall be provided with the following accessories:

(a) Top and bottom shut off valve
(b) Drain Valve and sampling valve
(c) Air release plug
(d) Two grounding terminals for termination of two (2) Nos. 75x12 mm galvanisedsteel flats.
(e) Thermometer pockets with captive screw caps at cooler inlet and outlet.
(f) Lifting lugs

21.17.4 Each radiator bank shall be detachable and shall be provided with flanged inlet and outlet branches. Expansion joint shall be provided on top and bottom cooler pipe connection for separately mounted radiator bank.

21.17.5 If radiators are directly mounted on tank, sufficient number of thermometer pockets fitted with captive screw cap on the inlet and outlet of tank side pipe of radiators shall be provided to record temperature during temperature rise test.

21.17.6 The cooler pipes, support structure including radiators and its accessories shall be hot dip galvanised or corrosion resistant paint should be applied to external surface of it.

21.18 VALVES

21.18.1 All valves upto and including 100 mm shall be of gun metal or of cast steel/cast iron. Larger valves may be of gun metal or may have cast iron bodies with gun metal fittings. They shall be of full way type with internal screw and shall open when turned counter clock wise when facing the hand wheel.

21.18.2 Suitable means shall be provided for locking the valves in the open and close positions. Provision is not required for locking individual radiator valves.

21.18.3 Each valve shall be provided with the indicator to show clearly the position of the valve.

21.18.4 All valves' flanges shall have machined faces.

21.18.5 All valves in oil line shall be suitable for continuous operation with Reactor oil at 115 deg C.

21.18.6 The oil sampling point for main tank shall have two identical valves to be put in series. Oil sampling valve shall have provision to fix rubber hose of 10 mm size to facilitate oil sampling.

21.18.7 Valves or other suitable means shall be provided to fix the on line DGA monitoring systems to facilitate continuous monitoring. The location & size of the same shall be finalised during detail design review.

21.18.8 FLOW SENSITIVE CONSERVATOR ISOLATION VALVE

a) In order to restrict the supply of oil in case of a fire in Reactor, flow sensitive valve shall be provided to isolate the conservator oil from the main tank.

b) A valve which shall be flow sensitive and shut off when the flow in the pipe is more than the flow expected in the permissible normal operating conditions. This valve shall be located in the piping between the conservator and the buchholz relay and shall not affect the flow of oil from and to the conservator in normal conditions.

c) When the flow from conservator to main tank is more than the normal operating conditions, the valve shall shut off by itself and will have to be reset manually. It shall be provided with valve open/close position indicator along with alarm contact indication in control room during closing operation of valve. This valve shall be provided with locking arrangement for normal position and oil filling / filtration position. A suitable platform or ladder (if required) shall be provided to approach the valve for manual reset.

21.18.9 All valves shall be painted with a shade (preferably red or yellow distinct and differentfrom of main tank surface and as per the painting system and procedure specified.

21.18.10 All hardware used shall be hot dip galvanised / stainless steel.

21.19 CABLING

21.19.1 All interconnecting control and power cables between various parts of Reactors like turret CT, MBs, Buchholz, PRD etc. shall be routed through covered cable tray and shall be properly dressed. All cables shall be armoured type. Un-armoured cables (if provided) in any circuitry, shall be through GI conduit and no part shall be exposed. Cable terminations shall be through stud type TB and ring type lugs. Typical Technical specification for cables is attached at **Annexure-J**. Contractor shall provide type tested cables from approved sources. No type testing for cables is envisaged. Further, any special cables (if required) shall also be considered included in the scope. All cable accessories such as glands, lugs, cable tags/ numbers etc as required shall be considered included in the scope of supply.

21.19.2 Cabling of spare unit with isolator switching arrangement shall be in such a way that spare unit of reactor can be connected in place of faulty unit without physically shifting and all the control, protection, indication signals of spare unit shall be brought in common marshalling box of all the banks. From CMB all the control, protection and indication signals of R, Y, B and Spare units shall be transferred to Employer’s C & R panels / SCADA. Change-over of spare unit signals with faulty unit shall be done through Employer’s C & R panels / SCADA level.

21.20 INDIVIDUAL MARSHALLING BOX AND COMMON MARSHALLING BOX

21.20.1 Common Marshalling Box (for a bank of three single phase unit) whereas each three-phase shunt reactor shall be provided with Marshalling Box.

21.20.2 All out-door control cabinets shall be made of stainless-steel sheet of at least 1.6 mm thick. The degree of protection shall be at least IP: 55 for outdoor and IP: 43 for indoor in accordance with IS: 13947/IEC: 60947.

21.20.3 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, 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. Ventilating Louvers, if provided, shall have screen and filters. The screen shall be fine wire mesh of brass. All the separately mounted cabinets and panels shall be free standing floor mounted type and have domed or sloping roof. All the control cabinets shall be provided with suitable lifting arrangement. Individual Marshalling Box shall be tank mounted only.

21.20.4 All the contacts of various protective devices mounted on the reactor and all the secondary terminals of the bushing CTs shall also be wired upto the terminal board in the Marshalling box. All the CT secondary terminals in the Marshalling box shall have provision for shorting to avoid CT open circuit while it is not in use. All the necessary terminations for remote connection to Employer's panel shall be wired upto the Common Marshalling box.

21.20.5 A space heater and cubicle lighting with ON-OFF switch shall be provided in each panel.

21.20.6 Control and power supplies are to be given after suitable selection at Common Marshalling Box. Necessary isolating switches and protective devices shall be provided at suitable points as per Employer's approved scheme.

21.20.7 All the control circuit connections from Individual Marshalling Box and of three single phase units of a bank including spare reactor unit to Employers Control panels shall be routed through common marshalling box. Common marshalling box shall be floor mounted and of size not less than 1600mm (front) X 650mm (depth) X 1800mm (height).

21.20.8 Details of station auxiliary power supply are mentioned in Section - GTR. Common marshalling box shall have following arrangement:

i. Two auxiliary power supplies, 415 volt, three phase four (4) wire shall be provided by the Employer at Common Marshalling Box (for Single Phase unit) or Marshalling Box(for Three Phase unit).

ii. Suitably rated power contactors, MCBs/MCCBs as required for entire auxiliary power supply system including distribution to marshalling boxes, Online DGA monitoring system, Online drying system and Fibre optic sensor Box etc., shall be provided by contractor. For each circuit separate MCBs / MCCBs shall be provided in the Common Marshalling Box.

iii. In case auxiliary power supply requirement is different than station auxiliary AC supply, then all necessary converters shall be provided by the Contractor. Auxiliary power supply distribution scheme shall be submitted for approval.

21.20.9 All loads shall be fed by one of the two feeders through an electrically interlocked automatic transfer scheme housed in the common marshalling box. Design features of the transfer scheme shall include the following:

a) Provision for the selection of one of the feeder as normal source and other asstandby.
b) Upon failure of the normal source, the loads shall be automaticallytransferred after an adjustable time delay to standby sources.
c) Indication to be provided at marshalling box for failure of normal source andfor transfer to standby source and also for failure to transfer.
d) Automatic re-transfer to normal source without any intentional time delayfollowing re-energization of the normal source.
e) Both the transfer and the re-transfers shall be dead transfers and AC feedersshall not be paralleled at any time.

21.21 SCADA INTEGRATION

All the online monitoring equipment i.e., Optical Temperature Sensors & Measuring Unit, Online Dissolved Gas (Multi-gas) and Moisture Analyser, On-line insulating oil drying system (Cartridge type) provided for individual reactor unit including spare (if any), are IEC 61850 compliant (either directly or through a Gateway). This monitoring equipment are required to be integrated with SAS through managed Ethernet switch conforming to IEC 61850. This Ethernet switch shall be provided in MB (for 3-ph unit) by the contractor. The switch shall be powered by redundant DC supply (110V or as per available Station DC supply). Ethernet switch shall be suitable for operation at ambient temperature of 50 Deg C. All required power & control cables including optical cable, patch chord (if any) upto MB (for 3-Ph unit) shall be in the scope of contractor. Further, any special cable between MB (for 3-Ph unit) to switchyard panel room/control room shall be in the scope of contractor.

However, fiber optic cable, power cable, control cables, as applicable, between MB (for 3-Ph unit) to switchyard panel room/control room and power supply (AC & DC) to MB and integration of above said IEC-61850 compliant equipment with Substation Automation System shall be under the scope of sub-station contractor.

21.22 CURRENT TRANSFORMER (BUSHING & OUTDOOR NEUTRAL CURRENT TRANSFORMER)

21.22.1 Current transformers shall comply with IEC-61869-1 and 61869-2.

21.22.2 It shall be possible to remove the turret mounted current transformers from the Reactor tank without removing the tank cover. Necessary precautions shall be taken to minimize eddy currents and local heat generated in the turret.

21.22.3 Current transformer secondary leads shall be brought out to a weatherproof terminal box near each bushing. These terminals shall be wired out to common marshalling box using separate cables for each core.

21.22.4 For 1-Phase Reactor, one number single phase current transformer (outdoor) for earth fault protection shall be provided for each bank of reactor and shall be located in the neutral conductor connecting common neutral point with earth.

21.22.5 Technical Parameters of Bushing CTs and Neutral CTs are enclosed at Annexure – H. The CT's used for REF protection must have the identical parameters in order to limit the circulating current under normal condition for stability of protection. 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.

21.22.6 Secondary resistance and magnetising current characteristics of PX / PS class (protection) (as per IS or IEC) CT of same rating shall match. This is applicable for Neutral CT (outdoor) also and shall be reviewed during detail engineering.

21.23 SURGE ARRESTER

21.23.1 General

The surge arresters shall conform in general to IEC-60099-4 except to the extent explicitly modified in the specification. The bidder shall offer surge arresters of gapless type without any series or shunt gap. Arresters shall be hermetically sealed units, of self-supporting construction, suitable for mounting on structures.

21.23.2 Duty Requirements

The surge arresters shall be of heavy-duty station class type. It shall be physically located between the neutral of shunt reactor (brought out at bushing) and neutral grounding reactor and shall be electrically in parallel with the latter.

The surge arresters shall be capable of discharging over voltage occurring during switching of unloaded transformers and reactors. It shall be capable of spark over on severe switching surges and multiple strokes. It shall be able to withstand wind load calculated at 195 kg/sq.m.

21.23.3 Constructional Features

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

21.23.3.2 The reference current of the arrester shall be high enough to eliminate the influence of grading and stray capacitance on the measured reference voltage.

21.23.3.3 The surge arresters shall be fitted with pressure relief devices and arc diverting parts suitable for preventing rupture of polymer housing and providing path for flow of rated fault currents in the event of arrester failure.

21.23.3.4 The arresters shall incorporate anti-contamination feature to prevent arrester failure consequent to uneven voltage gradient across the stack in the event of contamination of the arrester housing.

21.23.3.5 Seals shall be provided in such a way that these are always effectively maintained even when discharging rated lightning current.

21.23.3.6 Outer insulator shall be polymer / composite insulator housing. Details specification of polymer/composite insulators are given in clause 11.7

21.23.3.7 The end fittings shall be made of non-magnetic and corrosion proof material.

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

21.23.3.9 The arrester shall be supplied with suitable support structure either of tubular GI pipe or lattice steel galvanised.

21.23.3.10 The heat treatment cycle details along with necessary quality checks used for individual blocks along with insulation layer formed across each block to be furnished. Metallised coating thickness for reduced resistance between adjacent discs to be furnished along-with procedure for checking the same.

21.23.3.11 Technical parameters of Surge Arrester are enclosed at Annexure-I

21.23.4 FITTINGS AND ACCESSORIES

21.23.4.1 Each arrester shall be complete with insulating base, support structure and terminal connector. The height of the support structure shall not be less than 2500 mm. The structure would be made of galvanized steel generally conforming to IS: 802. The surge arrester can also be mounted on the neutral grounding reactor in lieu of separate support structure.

21.23.4.2 Self contained discharge counter, suitably enclosed for outdoor use and requiring no auxiliary or battery supply for operation along with necessary connection, shall be provided for each unit. The counter shall be visible through an inspection window from ground level. The counter terminals shall be robust and of adequate size and shall be so located that incoming and outgoing connections are made with minimum possible bends. One no. potential free change over type contacts (rated for 220V DC) shall be provided for monitoring of surge counter operation in substation automation system.

21.23.4.3 Suitable milli-Ammeter on each arrester with appropriate connections shall be supplied to measure the resistor grading leakage current. The push buttons shall be mounted such that it can be operated from ground level.

21.23.4.4 Discharge counter and milli-ammeter shall be suitable for mounting on support structure of the arrester with minimum protection class IP 55.

21.23.4.5 Grading/Corona rings shall be provided on each complete arrester unit as required for proper stress distribution.

21.23.5 Tests

i. The surge arresters shall conform to type tests and shall be subjected to routine tests asper IEC-60099-4.

ii. Surge arrester shall be subjected to additional acceptance tests.

- Polymer insulator test as per IEC 61462
- Construction check (visual check)
- Measurement of insulation resistance by 1kV megger.

21.24 HAND TOOLS

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 used - 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), bushing handling and lifting tools with nylon rope/belt, chain block (2 Nos.) and D-Shackle shall besupplied.

21.25 TEST KIT

- BDV Kit as per Annexure-K of specification
- PORTABLE DGA KIT AS PER ANNEXURE-K OF SPECIFICATION

21.26 FITTINGS

The following fittings shall be provided with each shunt reactor and for neutral grounding reactor (as applicable) covered under this specification.

21.27 SHUNT REACTOR

i) Conservator for main tank of reactor with aircell, isolating valves, drain valve, magnetic oil level gauge with potential free high and low oil level alarm contacts and prismatic oil level gauge and Dehydrating Silicagel Filter Breather with flexible connection pipes to be used during replacement of anysilicagel breather

ii) Pressure relief devices with trip contact

iii) Sudden pressure relief relay with alarm contact

iv) Buchholz relay with isolating valves on both sides, bleeding pipe with petcock at the end to collect gases and alarm / trip contacts.

v) Air release plug

vi) Inspection openings and covers

vii) Bushing of each type with metal parts and gaskets to suit the terminationarrangement

viii) Winding & Oil temperature indicators

ix) Cover lifting eyes, reactor lifting lugs, jacking pads, towing holes and coreand winding lifting lugs

x) Rating and diagram plates on reactors and auxiliary apparatus

xi) Roller Assembly (as per clause 7.4)

xii) Marshalling Box, Common Marshalling Box (applicable for 1-Ph unit), Fibreoptic sensor box as applicable

xiii) Cooling equipment

xiv) Drain valves/plugs shall be provided in order that each section of pipe workcan be drained independently

xv) Bushing Current Transformers, Neutral CT (if applicable)

xvi) Terminal marking plates

xvii) Valves schedule plate

xviii) Bottom oil sampling valve, Drain valves, Filter valves at top and bottom withthreaded male adaptors, Shut off valves on the pipe connection between radiator bank and reactor tank, Shut off valves on both sides of Buchholz relay, Sampling gas collectors for Buchholz relay at accessible height, Valves for Radiators, Valve for vacuum application, Valve for on line DGA, valves for Drying out system, Valve for UHF sensors, valves for NIFPS system (if applicable) etc.

xix) Suitable terminal connectors on bushings and surge arrester

xx) Ladder to climb up to the Reactor tank cover with suitable locking arrangement to prevent climbing during charged condition.

xxi) Suitable Platform or ladder for safe access of Flow sensitive non-return valve and buchholz relay shall be provided, in case these are not accessible from Reactor top.

xxii) Haulage lugs

xxiii) Fibre optic sensor based temperature measuring system (applicable for 400kV Reactor)

xxiv) Two earthing terminals each on shunt reactor tank, radiators & marshalling boxes, SA structures etc.

xxv) Neutral bus connection arrangement (3-Phase Transformer)

xxvi) Online Dissolved Gas (Multi-gas) and Moisture Analyser (if specified inBPS) as per **Annexure-L**

xxvii) On Line Dissolved Hydrogen and Moisture Monitor (if specified in BPS) asper **Annexure-M**

xxviii) On-line insulating oil drying system (Cartridge type) (if specified in BPS)as per **Annexure-N**

xxix) Nitrogen Injection Type Fire Protection System (NIFPS) (if specified inBPS) as per **Annexure-O**

xxx) Oil Sampling Bottle & Oil Syringe (if specified in BPS) as per **Annexure-P**

21.28 NGR

i) Conservator for NGR main tank with drain valve, isolating valve, vent pipeand prismatic oil level gauge.

ii) Pressure relief devices with trip contact

iii) Buchholz relay with isolating valves on both sides, bleeding pipe with petcock at the end to collect gases and alarm / trip contacts.

iv) Air release plug

v) Inspection openings and covers

vi) Bushings with metal parts and gaskets to suit the termination arrangement

vii) Oil temperature indicators

viii) Cover lifting eyes, reactor lifting lugs, jacking pads, towing holes and coreand winding lifting lugs

ix) Rating and diagram plates

x) Roller Assembly (if applicable as per clause 7.4)

xi) Marshalling Box (Tank mounted)

xii) Cooling equipment as applicable

xiii) Bushing Current Transformers, Neutral CT (if applicable)

xiv) Drain valves/plugs shall be provided in order that each section of pipe workcan be drained independently

xv) Terminal marking plates

xvi) Valves schedule plate

xvii) Bottom oil sampling valve with threaded male adaptors, Drain valves, Filter valves at top and bottom, shut off valves on both sides of Buchholz relay at accessible height, Sampling gas collectors for Buchholz relay at accessible height, Valve for vacuum application etc.

xviii) Suitable terminal connectors on bushings

xix) Ladder to climb up to the tank cover with suitable locking arrangement to prevent climbing during charged condition.

xx) Haulage lugs

xxi) Two earthing terminals each on tank, marshalling boxes etc.

The fittings listed above are only indicative and any other fittings which are generally required for satisfactory operation of the reactors are deemed to be included. All hardware used shall be hot dip galvanised / stainless steel.

21.29 INSPECTION AND TESTING

The Contractor shall carry out a comprehensive inspection and testing programme during manufacture of the equipment. The inspection envisaged by the Purchaser is given below. This is however not intended to form a comprehensive programme as itis 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. All accessories and components of transformer shall be purchased from approved soured of Employer. All process tests, critical raw material tests and witness / inspection of these testing shall be carried out as per approved manufacturing quality plan (MQP)by Employer.

21.30 FACTORY TESTS

The manufacturer shall be fully equipped to perform all the required tests as specified. The contractor shall bear all additional costs related to tests which are not possible to carry out at his own works.

The contractor shall carry out type & routine tests as per "Annexure-B & Annexure- C". All tests shall be done in line with IEC: 60076 and the test procedures as mentioned in "Annexure-C". Complete test report shall be submitted to Employer after proper scrutiny and signing on each page by the test engineer of the contractor.

21.31 TYPE TESTS ON FITTINGS:

Following fittings shall conform to type tests and the type test reports shall be furnished by the contractor along with drawing of the equipment / fittings as per the Section – GTR. However, approval of drawings, GTP and type test reports for following fittings shall not be required, if the make and models are as per EMPLOYER's Compendium of Vendor (COV).

1) Bushing (Type Test as per IEC:60137 including Snap back & Seismic test for400 kV and above voltage class bushing)
2) Buchholz relay
3) OTI & WTI
4) Pressure Relief device Test (including IP 55 test in terminal box)
5) Sudden Pressure Relay Test (including IP 55 test in terminal box)
6) Magnetic Oil Level gauge & Terminal Box for IP-55 degree of protection.
7) Air Cell (Flexible air separator) - Oil side coating, Air side under Coating,Air side outer coating and coated fabric as per IS: 3400/ BS: 903/ IS: 7016
8) Marshalling & common marshalling box (IP-55 test)

21.32 PRE-SHIPMENT CHECKS AT MANUFACTURER'S WORKS

21.32.1 Check for inter-changeability of components of similar reactor for mounting dimensions.

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

21.32.3 Ensure following setting of impact recorder at the time of installation with Reactor unit before dispatch from factory:

1g: Start recording
2g: Warning
3g: Alarm

Further, drop-out setting shall be 1g and threshold setting shall be in the range of 5g to10g.

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

21.32.5 Gas tightness test to confirm tightness and record of dew point of gas inside the tank. Derivation of leakage rate and ensure the adequate reserve gas capacity.

21.33 INSPECTION AND TESTING AT SITE

The Contractor shall prepare a detailed inspection and testing programme for field activities covering areas right from the receipt of material stage up to commissioning stage. An indicative inspection programme as envisaged by the Employer is given below. Testing of oil sample at site shall be carried out as per specification. Contractorshall follow Employer Field Quality Plan (FQP).

21.34 RECEIPT AND STORAGE CHECKS

21.34.1 Check and record condition of each package, visible parts of the reactor etc. for any damage.
21.34.2 Check and record the gas pressure in the reactor tank as well as in the gas cylinder.
21.34.3 Visual check for wedging of core and coils before filling up with oil and also check conditions of core and winding in general.
21.34.4 Check and record reading of impact recorder at receipt and verify the allowable limits as per manufacturer's recommendations.

21.35 INSTALLATION CHECKS

21.35.1 Check whole assembly for tightness, general appearance etc.

21.35.2 Oil leakage test

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

21.35.4 Measure and record the dew point of gas in the main tank before assembly.

21.36 COMMISSIONING CHECKS

21.36.1 Check the colour of silicagel breather.

21.36.2 Check the oil level in the breather housing, conservator tanks, cooling system, condenser bushing etc.

21.36.3 Check the bushing for conformity of connection to the lines etc,

21.36.4 Check for correct operation of all protection devices and alarms/trip:

i. Buchholz relay
ii. Excessive winding temperature
iii. Excessive oil temperature
iv. Low oil level indication

21.36.5 Check for the adequate protection on the electric circuit supplying the accessories.

21.36.6 Check resistance of all windings. Insulation resistance measurement for thefollowing:

i) Control wiring
ii) Main windings
iii) Bushing Current Transformer

21.36.7 2 kV for 1 minute test between bushing CT terminal and earth.

21.36.8 Check for cleanliness of the reactor and the surroundings

21.36.9 Measure vibration and noise level

21.36.10 Capacitance and Tan delta measurement of winding and bushing

21.36.11 Frequency response analysis (FRA). FRA equipment shall be arranged by Employer.

21.36.12 DGA of oil just before commissioning and after 24 hours energisation at site.

21.36.13 Contractor shall prepare a comprehensive commissioning report including all commissioning test results as per Pre-Commissioning Procedures and handover to Employer for future record.

Annexure – A

TECHNICAL PARTICULARS / PARAMETERS OF 420KV SHUNT REACTOR

Claus eNo.	Description	Unit	Parameters
1.1	Rated Voltage, U_r (1p.u)	kV	420
1.2	Rated Capacity at 420 kV	MVAR	As per BPS
1.3	Standard		IEC 60076-6
1.4	Connection (3 Phase)		Star
1.5	Cooling System		ONAN
1.6	Frequency	Hz	50
1.7	No of Phases		3 (THREE)
1.8	Service		Outdoor
1.9	System Fault Level	kA	63
1.10	Permissible current unbalance among different phases	%	±2
1.11	Crest value of Third Harmonic content in phase current at ratedvoltage with sinusoidal wave form	%	≤ 3% of the crest value of fundamental
1.12	Range of constant Impedance (However, complete saturation characteristics of the Reactors upto 2.5 p.u. Voltage shall be furnished)		Up to 1.5 p.u.voltage
1.13	Tolerance on current	%	0 to +5%
1.14	Ratio of zero sequence reactance to positive reactance (X0/X1)	Range	0.9 - 1.0
1.15	Temperature rise over 50 deg C Ambient Temp at rated voltage		
	Top oil measured by thermometer	^{O}C	40
	Average winding measured by resistance method	^{O}C	45
1.16	Max. design Ambient temp	^{O}C	50
1.17	Windings		
a)	Lightning Impulse withstand Voltage		
	HV	kV_p	1300
	Neutral	kV_p	550
b)	Switching Impulse withstand Voltage		
	HV	kV_p	1050
c)	Power Frequency withstand Voltage		
	Neutral	kV_{rms}	230
d)	Tan delta of windings		< 0.005
1.18	Bushing		
a)	Rated voltage		

	HV	kV	420
	Neutral	kV	145
b)	Rated current (Min.)		
	HV	A	800
	Neutral	A	800
c)	Lightning Impulse withstand Voltage		
	HV	kVp	1425
	Neutral	kVp	650
d)	Switching Impulse withstand Voltage		
	HV	kVp	1050
e)	Power Frequency withstand Voltage		
	HV	kVrms	695
	Neutral	kVrms	305
f)	Minimum total creepage Distances		
	HV	mm	10500
	Neutral	mm	3625
g)	Tan delta of bushings		
	HV		< 0.004
	Neutral		< 0.004
h)	Max Partial discharge level at U_r		
	HV	pC	10
	Neutral	pC	10
1.19	Maximum Partial discharge levelat 1.58 $U_r / \sqrt{3}$	pC	100
1.20	Vibration and Tank stress level at rated voltage and frequency		Max: ≤ 200 microns peak to peak Average: ≤60 microns peak to peak. Stress: ≤ 2.0kg/sq.mm at any point ontank.
1.21	Maximum Noise level at rated voltage and frequency	dB	80
1.22	Maximum Permissible Losses of Reactor at rated Voltage, Frequency and at 75^{O} C (kW)		
i)	50MVAR, 420kV 3-Ph Reactor	kW	85
ii)	63MVAR, 420kV 3-Ph Reactor	kW	100
iii)	80MVAR, 420kV 3-Ph Reactor	kW	115
iv)	125MVAR, 420kV 3-Ph Reactor	kW	160

Notes:

Tan delta of Winding & Bushing shall be measured at ambient temperature. No temperaturecorrection factor shall be applied.

TECHNICAL PARTICULARS / PARAMETERS OF NEUTRAL GROUNDING REACTOR (NGR)

The neutral grounding reactors are generally used in Line Reactor between the neutral end of theReactor and ground to limit the secondary arc current and the recovery voltage to a minimum value.

Following are the technical particulars/ parameters envisaged for NGR:

Claus eNo.	**Descriptio n**	**Unit**	**Parameters**
4.	Technical Parameters		
	Rated voltage from insulation	kV	**145**
4.1	Connection		Between neutral of reactor and ground
4.2	Cooling System		Natural oil cooling (ONAN)
4.3	Cooling medium		Insulating oil
4.4	Frequency	Hz	50
4.5	No of Phases		1 (SINGLE)
4.6	Service		Outdoor
4.7	Type		Oil filled outdoor application
4.8	Insulation		Graded
4.9	Max. continuous current (rms)		10 A
4.10	Rated short time current (rms) (10secs.)		60A
4.11	Rated impedance at rated short time andcontinuous current		As specified in section project
4.12	Max. temperature rise over ambienttemperature of 50$^{\o}$C at rated voltage		
i)	of winding measured by resistance	Deg C	50
ii)	of top oil measured by thermometer	Deg C	45
4.13	Insulation level for winding		
	Lightning Impulse withstand Voltage		
i)	Line side	kV_p	550
ii)	Ground side	kV_p	95
	One Minute Power Frequency withstand Voltage		

Claus eNo.	Descriptio n	Unit	Parameters
iii)	Line side	kV_{rms}	230
iv)	Ground side	kV_{rms}	38
4.14	**Bushing**		
	Rated Voltage		
i)	Line side	kV	145
ii)	Ground side	kV	24
	Lightning Impulse withstand Voltage	kV_p	
iii)	Line side		650
iv)	Ground side		125
	One Minute Power Frequency withstand Voltage		
v)	Line side	kV_{rms}	305
vi)	Ground side	kV_{rms}	50
	Creepage (total minimum)		
vii)	Line side	mm	3625
viii)	Ground side	mm	600
4.15	Method of grounding		Solidly connected between neutral of shunt reactor andearth.
4.16	Whether neutral is to be brought out		Yes (through 24kV Porcelain bushing

Annexure -B

Test Plan

No.	Item	Test Category
1.	Measurement of winding resistance	Routine
2.	Reactance and loss measurement (Measured in Cold and Hot state for the unit on which temperature rise test isperformed & in Cold state for all other units)	Routine
3.	Measurement of insulation resistance & Polarization Index	Routine
4.	Measurement of insulation power factor and capacitance between winding andearth	Routine
5.	Measurement of insulation power factor and capacitance of bushings	Routine
6.	Core assembly dielectric and earthing continuity test	Routine
7.	High voltage withstand test on auxiliary equipment and wiring after assembly	Routine
8.	Chopped wave lightning impulse test for the line terminals (LIC)	Routine
9.	Lightning impulse test on Neutral	Routine
10.	Switching impulse test	Routine
11.	Applied voltage test (AV)	Routine
12.	Induced Over Voltage Test with Partial Discharge Measurement	Routine
13.	Gas-in-oil analysis	Routine
14.	2-Hour excitation test except type tested unit	Routine
15.	Vibration & stress measurement in Cold and Hot state for the unit on whichtemperature rise test is performed & in Cold state for all other units (Measurement shall also be carried out at 1.05Ur for reference only on one unit of each type)	Routine
16.	Temperature rise test	Type
17.	Measurement of harmonic content of current (Measured in Cold state)	Type
18.	Measurement of acoustic noise level (Measured in Cold and Hot state of temperature rise test)	Type
19.	Knee point voltage measurement of reactor (Measured in Cold state)	Type
20	Measurement of zero-sequence reactance (Applicable for three phase shunt reactor only)	Type

21.	Frequency Response analysis (Soft copy of test report to be submitted to site along with test reports)	Routine
22.	Appearance, construction and dimension check	Routine
23.	Oil leakage test on Reactor tank	Routine
24.	Tank vacuum test	Routine
25.	Tank pressure test	Routine

Test on NGR	
Item	**Test**
Measurement of winding resistance	Routine
Measurement of Impedance by V/I	Routine
Measurement of insulation resistance	Routine
Measurement of Capacitance & Tan delta of winding insulation to earth and	Routine
Lightning impulse test	Routine
Separate source voltage withstand test	Routine
Isolation Test	Routine
Oil leakage test	Routine
Appearance, construction and dimension check	Routine
High voltage with stand test on auxiliary equipment and wiring after assembly	Routine
Tank Vacuum test	Routine
Tank Pressure test	Routine

Annexure - C

Test Procedures

1. MEASUREMENT OF WINDING RESISTANCE

After the Reactor has been under oil without excitation for at least 3 h, the average oil temperature shall be determined and the temperature of the winding shall be deemed to be the same as the average oil temperature. The average oil temperature is taken as the mean of the top and bottom oil temperatures.

In measuring the cold resistance for the purpose of temperature-rise determination, special efforts shall be made to determine the average winding temperature accurately. Thus, the difference in temperature between the top and bottom oil shall not exceed 5 K. To obtain this result more rapidly, the oil may be circulated by a pump.

2. REACTANCE AND LOSS MEASUREMENT

- The type tested unit shall be measured in the cold and hot state.
- In other units, measurement shall be carried out in the cold state and corrected as perfactors derived from the type tested unit.
- Measurement shall also be carried out during 2-hour excitation test.

The following details shall be recorded under the heading of losses on the test certificate:

- Voltage reading
- Current reading
- CT & PT Ratio
- Tan delta
- the power reading
- total losses measured
- Total losses corrected to 75°C winding temperature
- the frequency reading
- the instrument constants and corrections (if any)
- The magnetization curve of the reactor (Type Tested unit)

3. MEASUREMENT OF INSULATION RESISTANCE & POLARIZATION INDEX

Measurement of D.C. insulation resistance between each winding to earth and between windings shall be carried out at 5000V DC. The polarisation index is a ratio of insulation resistance value at the end of 10 min test to that at the end of 1 min test at a constant voltage. It is recommended that PI value shall be better than 1.3.

4. MEASUREMENT OF INSULATION POWER FACTOR AND CAPACITANCE BETWEEN WINDING ANDEARTH

Reactor shall be tested in GST mode only between winding to tank for the measurement of capacitance & tan delta of winding to earth by applying 2kV and 10kV. Tan delta of winding shall not exceed 0.5% at ambient temperature. No temperature correction factor shall be applied.

5. MEASUREMENT OF INSULATION POWER FACTOR AND CAPACITANCE OF BUSHINGS

Bushing shall be tested in UST mode by applying 10kV and 2kV. Tan delta of bushing shall not exceed 0.4% at ambient temperature. No temperature correction factor shall be applied.

6. CORE ASSEMBLY DIELECTRIC AND EARTHING CONTINUITY TESTS.

The insulation of the magnetic circuit and between the magnetic circuit and the core clamping structure, including core-bolts, bands and/ or buckles shall withstand the application of a test voltage of either 2 kVac or 3 kV dc for 60 seconds.

The insulation of core to tank, core to yoke clamp (frame) and yoke clamp (frame) to tank shall be able to withstand a voltage of 2 kV (DC) for 1 minute. Insulation resistance shall be minimum 1 GΩ for all cases mentioned above.

The continuity of the single-point earthing shall be verified before despatch. The results of the works tests shall be recorded on the test certificate, and shall include the resistance reading obtained from a measurement made between the core and core clamping structure by means of at least 1.5 kV ac or 2 kV dc. During erection, the contractor shall repeat this measurement at site. The records of these tests shall also be included in the test report.

7. DIELECTRIC TESTS

Following Tests (as applicable) shall be performed in the sequence given below as per IEC 60076-3:2013 clause 7.2.3 shall be followed:

a) Lightning impulse tests (LIC, LIN)
b) Switching impulse (SI)
c) Applied voltage test (AV)
d) Induced voltage test with partial discharge measurement

Testing shall be performed in line with IEC. DGA tests shall be performed before and after Dielectric Tests.

8. TWO HOURS EXCITATION TEST

- Each reactor to be excited at 1 p.u. for 2 hours except type tested unit.
- Measure reactance, loss and vibration
- DGA rate interpretation shall be as per IEC/ CIGRE/ IEEE guidelines
- Test shall be performed before partial discharge test

9. VIBRATION & STRESS MEASUREMENT

After all dielectric test reactor shall be energised at rated voltage and mark atleast 4 points on each side wall where vibration is more. Stress will be measured on the same points. Similar process shall be followed for 1.05Ur voltage.

Temperature rise test (As per IEC-60076)

Temperature rise shall be guaranteed and tested at rated voltage (1 p.u). The tests shall be done for a minimum of 24 hours with saturated temperature for at least 4 hours. DGA tests shall be performed before and after heat run test and DGA results shall generally conform to IEC61181.

During this test the following shall be measured.

- Voltage
- Current
- Reactance and loss
- Audible sound
- Vibration
- Colour photographs of the four sides and top of the reactor together with the corresponding series of thermal images (colour) during starting and end of the test. Itis also recommended to take thermal images 4 more times to take care of any unforeseen situation.
- Temperature measurement with internal probes during test.

The heat run type test results shall serve as a “finger print” for the other units to beroutine tested.

Specified winding hotspot temperatures shall not be exceeded.

The temperature rises recorded by infra red shall not be more than 10°C above top oiltemperature or 15°C above the local oil temperature.

Full details of the test arrangements, procedures and conditions shall be provided with thetest certificates and the following shall at least be included.

- Purchaser’s order number and reactor site designation.
- Manufacturer’s name and reactor serial number.
- Ratings of reactor:
- MVA
- Voltage:
- Frequency
- Rated currents:
- Class of cooling
- Measured load losses at 75° C.
- Altitude of test bay.

3.3 TOP OIL TEMPERATURE RISE TEST

A log of the following parameters taken at 30 minute intervals:

- time
- Voltage
- Current
- Total power
- Ambient temperature measured on not less than three thermometers
- Top oil temperature: and
- Cooler inlet and outlet oil temperatures.
- Infra red pictures during the heating up phases

3.4

3.5 WINDING TEMPERATURE RISE TEST

- Record the weight of conductor in each winding, and the losses in watts perkilogram, the 'cold' resistance of each winding and the simultaneous top oil and ambient air temperatures, together with the time required for the effect todisappear.
- Record the thermal time constant of the winding.
- Log the half–hourly readings of the parameters as for the top oil temperaturerise test.
- Provide a table of readings, after shut-down of power, giving the followinginformation;

    - Time after shut- down:
    - Time increment:
    - Winding resistance: Record the resistance values for minimum 20minutes.
    - Resistance increment:
    - X, where x is the time after shut-down divided by the thermal timeconstant of the winding: and
    - Y, where Y = 100 (1-e $^{-x}$)

- (Any graphical/computer method used to determine the temperature of a winding by extrapolation to the instant of power shut-down shall produce a linear curve.)
- Provide a record of all calculations, corrections and curves leading to the determination of the winding temperatures at the instant of shut-down of power.
- Record any action taken to remedy instability of the oil surge device during initiation of the oil circulating pumps.

Temperature measurements as per special probes or sensors placed at various locations shall also be recorded.

10. MEASUREMENT OF HARMONIC CONTENT OF CURRENT (MEASURED IN COLD STATE)

The harmonics of the current in all three phases are measured at rated voltage, by means of a harmonic analyser. The magnitude of the relevant harmonics is expressed as a percentage of the fundamental component. For more information on the magnetic characteristic, see Annex B of IEC 60076-6. The harmonics of the applied voltage shall be adequately measured at the same time.

11. MEASUREMENT OF ACOUSTIC NOISE LEVEL (MEASURED IN COLD AND HOT STATE OFTEMPERATURE RISE TEST)

Test shall be performed as per clause 7.8.12 of IEC 60076-6 and IEC 60076-10. The measured value shall not be exceeded the limit as specified at Annexure-A of thisspecification.

12. KNEE POINT VOLTAGE MEASUREMENT OF REACTOR (MEASURED IN COLD STATE)

The test shall be carried out as per IEC 60076-6 clause B.7.1 “DC current charging – discharging method (theory)” or applying AC voltage from 0.7p.u, 0.8p.u, 0.9p.u and so on upto the level as per specification and measure the current at various voltages and calculate the tolerance of reactance as per annexure-A of this specification.

13. MEASUREMENT OF ZERO-SEQUENCE REACTANCE (APPLICABLE FOR THREE PHASE SHUNT REACTORS ONLY)

THE TEST SHALL BE GENERALLY PERFORMED AS PER IEC 60076-1. THIS MEASUREMENT SHALL BE CARRIED OUT AT A VOLTAGE CORRESPONDING TO A NEUTRAL CURRENT EQUAL TO THE RATED PHASE CURRENT.

14. FREQUENCY RESPONSE ANALYSIS

The test shall be performed on each phase of the Reactor by taking open circuit response of complete winding as HV to neutral terminal and vice versa. The response shall be compared with other units of same design for reference.

FRA shall also be carried out without oil in main tank for reference purpose.

15. OIL LEAKAGE TEST ON REACTOR TANK & NGR

All tanks and oil filled compartments shall be 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 subjected to a pressure equal to normal head of oil plus 35 kN/sq.m(5 psi) measured at the base of the tank. This pressure shall be maintained for a period of not less than 12 hours for oil and 1 hour for air during which no leakage shall occur.

16. TANK VACUUM TESTS

All shunt reactor & NGR tanks 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 plates after the vacuum has been released shall not exceed the values specified below:

Horizontal length of deflectionflat plate (in mm)	Permanent (in mm)
Upto and including 750	5.0
751 to 1250	6.5
1251 to 1750	8.0
1751 to 2000	9.5
2001 to 2250	11.0
2251 to 2500	12.5
2501 to 3000	16.0
above 3000	19.0

17. TANK PRESSURE TEST

All shunt reactor & NGR tanks of each size, its radiator, conservator vessel and other fittings together or separately shall be subjected to a pressure corresponding to twice the normal head of oil or normal oil head pressure plus 35 KN/sq.m whichever is lower, measured at the base of the tank and maintained for one hour. The permanent deflection of the flat plate after the excess pressure has been released shall not exceed the figures specified above for vacuum test.

18. ROUTINE TESTS ON NEUTRAL GROUNDING REACTOR

In addition to the routine tests listed in the IEC-60076 & Annexure- C of this specification, the volt-current characteristics test shall also be carried out on each neutral grounding reactor preferably at least upto short time rated current. Calculated value of hot spot temperature shall be furnished by the Contractor. Further, Lighting impulse voltage withstand test and ohmic value measurement shall also be carried out.

19. Routine tests on Bushings: Routine test on bushings shall be done as per IEC 60137.

ANNEXURE – E

Design Review Document for Shunt Reactor

Sr. No.	Description
1.	Core and Magnetic Design
2.	Over-fluxing and Linear characteristics
3.	Inrush-current characteristics while charging
4.	Winding and winding clamping arrangements
5.	Short-circuit withstand capability considering inrush current.
6.	Thermal design including review of localised potentially hot area
7.	Cooling design
8.	Overload capability
9.	Eddy current losses
10.	Seismic design, as applicable
11.	Insulation co-ordination
12.	Tank and accessories
13.	Bushings
14.	Protective devices
15.	Radiators
16.	Sensors and protective devices– its location, fitment, securing and level of redundancy
17.	Oil and oil preservation system
18.	Corrosion protection
19.	Electrical and physical Interfaces with substation
20.	Earthing (Internal & External)
21.	Processing and assembly
22.	Testing capabilities
23.	Inspection and test plan
24.	Transport and storage
25.	Sensitivity of design to specified parameters
26.	Acoustic Noise
27.	Spares, inter-changeability and standardization
28.	Maintainability
29.	PRD and SPR (number & locations) and selection
30.	Conservator capacity calculation
31.	Winding Clamping arrangement details with provisions for taking it “in or out of tank”
32.	Conductor insulation paper details
33.	Location of Optical temperature sensors
34.	The design of all current connections

35.	Location & size of the Valves

Note: Design review document for NGR shall be decided during detailed engineering.

ANNEXURE – F

Painting Procedure

PAINTING	Surface preparation	Primer coat	Intermediate undercoat	Finish coat	Total dry film thick-ness (DFT)	Colour shade
Main tank, pipes, conservator tank, oil storage tank& DM Box 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 (above80 NB), conservator tank, oil storage tank & DM Box etc. (Internal surfaces)	Shot Blast cleaning Sa 2 ½*	Hot oil proof ,low Viscosity varnish or Hot oil resistant, non-Corrosive Paint	--	--	Minimum 30μm	Glossy white forpaint
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 oftank/ differen tshade aesthetically matching to tank
	contractor may also offer Radiators with hot dip galvanised in place of painting with minimum thickness of 40μm (min)					
Radiator andpipes up to 80 NB (Internal surfaces)	Chemical cleaning, ifrequired	Hot oil proof, low viscosity varnish orHot oil resistant, non-	--	--	--	--

		Corrosive Paint				
Control cabinet / Marshalling Box/Common Marshalling Box - No painting is required.						

Note: (*) indicates Sa 2 ½ as per Swedish Standard SIS 055900 of ISO 8501 Part-1.

ANNEXURE – G

Unused inhibited Insulating Oil Parameters

Sl. No.	Property	Test Method	Limits
A	**Function**		
1a.	Kinematic Viscosity at 40 °C	IS 1448 Part 25 or ISO 3104 or ASTM D7042	12 mm^2/s (Max.)
1b.	Kinematic Viscosity At -30 °C		1800 mm^2/s (Max.)
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	IS 1448 Part 10/Sec 2 or ISO 3016	-40 °C (Max.)
4.	Water content a) for bulk supply b) for delivery in drums	IEC 60814	 30 mg/kg (Max.) 40 mg/kg (Max.)
5.	Electric strength (breakdown voltage)	IS 6792 or IEC 60156	Minimum 30 kV (new unfiltered oil) / 70 kV (after treatment)
6.	Density at 20 °C	IS 1448 Part 16 or ISO 12185 or ISO 3675 or ASTM D7042	895 kg/m^3 (Max.)
7.	Dielectric dissipation factor (tan delta) at 90 °C	IS 16086 or IEC 60247 or IEC 61620	0.0025 (Max.)
8.	Negative impulse testing KVp @ 25 °C	ASTM D3300	145 (Min.)
B	**Refining/Stability**		
1.	Colour	ISO 2049	Max. 1.5
2.	Appearance	–	Clear, free from sediment and suspended matter
3.	Neutralization Value (Total Acidity)	IEC 62021-1 or IEC 62021-2	0.01 mg KOH/g (Max.)
4.	Interfacial tension at	IEC 62961 or ASTM D971	0.04 N/m (Min.)

	27°C		
5.	Corrosive sulphur	DIN 51353	Non-Corrosive on copper and paper
6.	Potentially corrosivesulphur	IEC 62535	Non-Corrosive
7.	Presence Of oxidation inhibitor	IS 13631 or IEC 60666	Not detectable (<0.01%)
8.	DBDS	IEC 62697-1	Not detectable (<5 mg/kg)
9.	Metal passivator Additives	IEC 60666	Not detectable (<5 mg/kg)
10.	2-Furfural And related compound content	IS 15668 or IEC 61198	Not detectable (<0.05 mg/kg) for each individual compound
C	**Performance**		

1.	Oxidationstability	IEC 61125 (method c) Test duration: 164 hours	
	-Total acidity*	4.8.4 of IEC 61125:2018	1.2 mg KOH/g (Max.)
	-Sludge*	4.8.1 of IEC 61125:2018	0.8 % (Max.)
	-Dielectric Dissipation Factor* (tan delta) at 90 °C	4.8.5 of IEC 61125:2018	0.5 (Max.)
	*values at the end of oxidation stability test		
D	**Health, safety and environment (HSE)**		
1.	Flash point	IS 1448 Part 21 or ISO 2719	135 °C(Min.)
2.	Poly Cyclic Aromatic (PCA) content	IP 346	<3%
3.	Poly Chlorinated Biphenyl (PCB) content	IS 16082 or IEC 61619	Not detectable (< 2 mg/kg)

Note:
Supplier shall declare the chemical family and function of all additivesand the concentrations in the cases of inhibitors, antioxidants and passivators.

I. Oil used for first filling, testing and impregnation of active parts atmanufacturer's works shall meet parameters as mentioned below

1	Break Down voltage (BDV)	-	70kV (Min.)
2	Moisture content	-	5 ppm (Max.)
3	Tan-delta at 90°C	-	0.005 (Max.)
4	Interfacial tension	-	0.04 N/m (Min.)

II Each lot of the oil shall be tested prior to filling in main tank at sitefor the following:

1	Break Down voltage (BDV)	-	70 kV (Min.)
2	Moisture content	-	5 ppm (Max.)
3	Tan-delta at 90°C	-	0.0025 (Max.)
4	Interfacial tension	-	0.04 N/m (Min.)

III After filtration & settling and prior to energization at site oil shallbe tested for following:

1	Break Down voltage (BDV)	-	70 kV (Min.)
2	Moisture content at hot condition	-	5 ppm (Max.)
3	Tan-delta at 90°C	-	0.005 (Max.)
4	Interfacial tension	-	0.04 N/m (Min.)
5	*Oxidation Stability	-	
	a) Acidity		0.3 (mg KOH /g) (Max.)- For Inhibited Oil 1.2 mg KOH/g (Max.)- For Uninhibited Oil
	b) Sludge	-	0.05 % (Max.) - For Inhibited Oil 0.8 % (Max.) - For Uninhibited Oil
	c) Tan delta at 90 °C	-	0.05 (Max.) - For Inhibited Oil 0.5 (Max.) - For Uninhibited Oil
6	Total PCB content*		Not detectable (< 2 mg/kg)
	* Separate oil sample shall be taken and test results shall be submittedwithin 45 days after commissioning for approval of the utility		

ANNEXURE – H

TECHNICAL PARAMETERS OF CURRENT TRANSFORMERS - 420 KV SHUNT REACTOR

On each phase connection & Neutral Grounding Reactor (NGR)

(a) Ratio	**Shunt Reactor**			**NGR**
	Line Side	Neutral Side	Common Neutral Side	Earth Side
CORE 1	200/1A	200/1A	200/1A	200/1A
CORE 2	200/1A	To be decided by contractor for WTI	-	-
CORE 3	200/1A	3000-2000-500/1A	-	-
CORE 4	200/1A	3000-2000-500/1A	-	-
(b) Minimum knee point voltage or burden and accuracy class				
CORE 1	200V, PX / PS Class	300V, PX / PS Class	200V, PX / PS Class	200V, PX / PS Class
CORE 2	200V, PX / PS Class	To be decided by contractor for WTI	-	-
CORE 3	200V, PX / PS Class	3000-2000-500V, PX / PS Class	-	-
CORE 4	10VA, Class 1.0	3000-2000-500V, PX / PS Class	-	-
(c) Maximum CT Secondary Resistance				
CORE 1	1 Ohm	1 Ohm	1 Ohm	1 Ohm
CORE 2	1 Ohm	-	-	-
CORE 3	1 Ohm	15-10-2.5 Ohm	-	-
CORE 4	-	15-10-2.5 Ohm	-	-
(d) Exciting current (max.)				
CORE 1	250mA @ vk/4	250mA @ vk/4	-	-
CORE 2	250mA @ vk/4	-	-	-
CORE 3	250mA @ vk/4	20mA @3000/1 30mA @ 2000/1 120mA @ 500/1	-	-
CORE 4	-	20mA @3000/1 30mA @ 2000/1 120mA @ 500/1	-	-
(e) Application				
CORE 1	Reactor Differential	Reactor Differential	Restricted earth fault	Restricted earth fault
CORE 2	Restricted earth fault	Temperature Indicator (on one phase only)	-	-
CORE 3	Reactor Backup	Line Protection (Main-I)/T zone differential Protection/spare	-	-

CORE 4	Metering	Line Protection (Main-II)/Tzone differential Protection/spare	-	-

NOTE:

i) For PX / PS class CT’s, Dimensioning parameter “K”, Secondary VA shall be considered 1.5 and 20respectively.
ii) Rated continuous thermal current rating shall be 200% of rated primary current.
iii) Parameters of WTI CT for each winding shall be provided by the contractor.
iv) For estimation of spares, one set of CTs shall mean one CT of each type used in Reactor & NGR.
v) The CT used for REF protection must have the identical parameters in order to limit the circulatingcurrent under normal condition for stability of protection.
vi) In case of single-phase reactor, Common Neutral Side shall be out door type.

ANNEXURE - I

Gapless Surge Arrester – Technical parameters

Claus eNo.	Description	Parameters
a.	Rated arrester voltage	120 kV
b.	Rated system voltage	145 kV
c.	Rated system frequency	50Hz
d.	System neutral earthing	Earthed through NGR
e.	Installation	Outdoor
f.	Nominal discharge current	10kA of 8/20 microsec wave.
g.	Class of arrester	10kA heavy duty type
h.	Minimum discharge capacity	3.5 kJ/kV (referred to rated voltage)
i.	Continuous operating voltage at 50°C	102 kV
j.	Maximum switching surge residual voltage (1kA)	280kVp
k.	Maximum residual voltage at	
	i) 10kA	320kVp
	ii)20kA nominal discharge current	340kVp
l.	Long duration discharge class	2
m.	High current short duration test value (4/10micro-sec.wave)	100kAp
n.	Current for pressure relief test	40kArms
o.	Low current long duration test value(2000microsec.)	1000Apeak
p.	Min. total creepage distance	3625 mm.
q.	One minute dry power frequency withstand voltage of arrester housing	275kVrms
r.	Impulse withstand voltage of arrester housingwith 1.2/50 micro-sec. wave	+ 650KVp
s.	Pressure relief class	A
t.	RIV at 92 kVrms.	Less than 500microvolts
u.	Partial discharge at 1.05 continuous over voltage	Not more than 50pC
v.	Seismic acceleration	As specified in section project
w.	Reference ambient temperature	50 deg C

ANNEXURE - J

1.1 KV GRADE POWER & CONTROL CABLES

1.1 All Power & Control cables shall be supplied from reputed vendors.`

1.2 Separate cables shall be used for AC & DC.

1.2 Separate cables shall be used for DC1 & DC2.

1.3 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. However, no spare cable is required for plug & socket type arrangement.

1.4 The Aluminium/Copper wires used for manufacturing the cables shall be true circular in shape before stranding and shall be uniformly good quality, free from defects. All aluminium used in the cables shall be of H2 grade.

1.5 The fillers and inner sheath shall be of non-hygroscopic, fire-retardant material, shall be softer than insulation and outer sheath shall be suitable for the operating temperature of the cable.

1.6 Progressive sequential marking of the length of cable in metres at every one metre shall be provided on the outer sheath of all cables.

1.7 Strip wire armouring method (a) mentioned in Table 5, Page-6 of IS: 1554 (Part 1) – 1988 shall not be accepted for any of the cables. For control cables only round wire armouring shall be used.

1.8 The cables shall have outer sheath of a material with an oxygen index of not less than 29 and a temperature index of not less than 250°C.

1.9 All the cables shall conform to fire resistance test as per IS: 1554 (Part - I).

1.10 The normal current rating of all PVC insulated cables shall be as per IS: 3961.

1.11 Repaired cables shall not be accepted.

1.12 Allowable tolerance on the overall diameter of the cables shall be plus or minus 2 mm.

1.13 PVC POWER CABLES

1.13.1 The PVC (70°C) insulated 1100V grade power cables shall be of FR type, C1 category, conforming to IS: 1554 (Part-I) and its amendments read along with this specification and shall be suitable for a steady conductor temperature of 70°C. The conductor shall be stranded aluminium. The Insulation shall be extruded PVC to type-A of IS: 5831. A distinct inner sheath shall be provided in all multi core cables. For multi core armoured cables, the inner sheath shall be of extruded PVC. The outer sheath shall be extruded PVC to Type ST- 1 of IS: 5831 for all cables. The contractor can use copper cable of required size.

1.14 PVC CONTROL CABLES

1.14.1 The 1100V grade control cables shall be of FR type C1 category conforming to IS: 1554 (Part-1) and its amendments, read along with this specification. The conductor shall be stranded copper. The insulation shall be extruded PVC to type A of IS: 5831. A distinct inner sheath shall be provided in all cables whether armoured or not. The over sheath shall be extruded PVC to type ST-1 of IS: 5831 and shall be grey in colour except where specifically advised by the Employer to be black.

1.14.2 Cores shall be identified as per IS: 1554 (Part-1) for the cables up to five (5) cores and for cables with more than five (5) cores the identification of cores shall be done by printing legible Hindu Arabic Numerals on all cores as per clause 10.3 of IS : 1554 (Part - 1).

STANDARD TECHNICAL DATA SHEET (1.1KV GRADE XLPE POWER CABLES)

Sr No	Description	Parameters	
1a	Cable Sizes	1 C x 630	3½ C x 300
b	Manufacturer's type designation	A2XWaY	A2XWY
2	Applicable standard	IS: 7098/PT-I/1988 & its referred specifications	
3	Rated Voltage(volts)	1100 V Grade	
4	Type & Category	FR & C1	FR & C1
5	Suitable for earthed or unearthed system	for both	
6	Continuous current rating when laid in air in an ambient temp. of 50 C and for maximum conductor temp. of 70 C of PVC Cables[For information only]	732	410
7	Rating factors applicable to the current ratings forvarious conditions of installation	As per IS-3961-Pt-II-67	
8	Short circuit Capacity		
a	Guaranteed Short Circuit Amp. (rms) KA for 0.12 sec duration at rated conductor temperature of 90degree C, with an initial peak of 105 KA	45kA	45kA
b	Maximum Conductor temp. allowed for the short circuit duty (deg C.) as stated above	250°C	
9	Conductor		
a	Material	Stranded Aluminium as per Class 2 of IS : 8130	
b	Grade	H 2 (Electrolytic grade)	
c	Cross Section area (Sq.mm.)	630	300/150
d	Number of wires(No.) minimum	53	30/15
e	Form of Conductor	Stranded and compacted circular	Stranded compacted circular/sector shaped
f	Direction of lay of stranded layers	Outermost layer shall be R.H lay & opposite insuccessive layers	
10	Conductor resistance (DC) at 20 °C per km- Maximum	0.0469	0.1/0.206
11	Insulation		
a	Composition of insulation	Extruded XLPE as per IS-7098 Part(1)	
b	Nominal thickness of insulation(mm)	2.8	1.8/1.4
c	Minimum thickness of insulation	2.42	1.52/1.16
12	Inner Sheath		
a	Material	Extruded PVC type ST-2 as per IS-5831-84	
b	Calculated diameter over the laid up	NA	52

	cores,(mm)		
c	Thickness of Sheath (minimum)mm	NA	0.6
d	Method of extrusion	NA	Pressure/Vacuum extrusion
13	Armour		
a	Type and material of armour	Al wire [H4 grade]	Gal. Steel wire
b	Direction of armouring	Left hand	
c	Calculated diameter of cable over inner sheath (under armour), mm	33.9	53.2
d	Nominal diameter of round armour wire (minimum)	2	2.5
e	Guaranteed Short circuit capacity of the armour for 0.12 sec at room temperature.	45kA	45kA
f	DC resistance at $20^{o}C$ (Ω/Km)	$	0.577
14	Outer Sheath	ST-2 & FR	ST-2 & FR
A	Material (PVC Type)	38.3	59.50
B	Calculated diameter under the sheath	1.72	2.36
C	Min. thickness of sheath(mm)	Min 29.0	Min 29.0
D	Guaranteed value of minimum oxygen index of outer sheath at $27^{o}C$	Min 250	Min 250
E	Guaranteed value of minimum temperature index at 21 oxygen index	Black	Black
f	colour of sheath	$	$
15 a	Nominal Overall diameter of cable	+2/-2 mm	
b	Tolerance on overall diameter (mm)	shall conform to IS 10418 and technical specification	
16	Cable Drums	1000/500	1000/500
a	Max./ Standard length per drum for each size ofcable (single length) with ±5% Tolerance (mtrs)		
b	Non-standard drum lengths	Maximum one(1) non-standard lengths of each cable size may be supplied in drums only over & above the standard lengths as specified above.(if required for completion of project)	
17	Whether progressive sequential marking on outersheath provided at1 meter interval 18	Yes	
18	Identification of cores		
a	colour of cores	As per IS 7098 Part(1)	
b	Numbering	NA	
19	Whether Cables offered are ISI marked	Yes	
20	Whether Cables offered are suitable for laying as per IS 1255	Yes	

$'- As per manufacturer design data

STANDARD TECHNICAL DATA SHEET - 1.1KV KV GRADE PVC POWER CABLES

SN	Description	Parameters					
1a	Cable Sizes	1 c x 150	3.5 cx 70	3.5 cx 35	4 c x 16	4c x 6	2 c x 6
1b	Manufacturer's type designation	AYWaY	AYFY	AYFY	AYFY	AYWY	AYWY
2	Applicable standard	IS: 1554/PT-I/1988 & its referred standards					
3	Rated Voltage(volts)	1100 V grade					
4	Type & Category	FR & C1	FR & C1	FR & C1	FR & C1	FR & C1	FR & C1
5	Suitable for earthed or unearthed System	for both					
6	Continuous current rating when laid in air in a ambient temp. of 50oC and for maximum conductortemp. of 70 oC of PVC Cables[For information only]	202	105	70	41	24	28
7	Rating factors applicable to the current ratings for variousconditions of installation:	As per IS-3961-Pt-II-67					
8	Short circuit Capacity						
a)	Short Circuit Amp. (rms)KA for 1 sec duration	11.2	5.22	2.61	1.19	0.448	0.448
b)	Conductor temp. allowed for the short circuit duty (deg C.)	160^{0}C					
9	Conductor						
a)	Material	STRANDED ALUMINIUM					
b)	Grade	H 2 (Electrolytic grade)					
c)	Cross Section area (Sq.mm.)	150	M-70 N-35	M-35 N-16	16	6	6
d)	Number of wires(No.)	as per Table 2 of IS 8130					
e)	Form of Conductor	Non-compacted Stranded circular	shaped conductor	shaped conductor	shaped conductor	Non-compacted Stranded circular	Non-compacted Stranded circular
f)	Direction of lay of stranded layers	Outermost layer shall be R.H lay & opposite in successive Layer					
10	Conductor resistance (DC) at 20oC per km-maximum	0.206	0.443/0 .868	0.868/ 1.91	1.91	4.61	4.61
11	Insulation						
a)	Composition of insulation	Extruded PVC type A as per IS-5831-84					
b)	Nominal thickness of insulation(mm)	2.1	1.4/1.2	1.2/1.0	1.0	1.0	1.0

c)	Minimum thickness of insulation	1.79	1.16/0.9 8	0.98/0. 8	0.8	0.8	0.8
12	Inner Sheath						
a)	Material	Extruded PVC type ST-I as per IS-5831-84					
b)	Calculated diameter over the laid up cores,(mm)	N.A	27.6	20.4	15.7	11.6	9.6
c)	Thickness of Sheath (minimum) Mm	N.A	0.4	0.3	0.3	0.3	0.3
13	Armour	as per IS 3975/88					
a)	a) Type and material of armour	Al. Wire[H4 grade]	Gal.steel Strip	Gal.steel strip	Gal.stee l strip	Gal.steel wire	Gal.steel wire
b)	b) Direction of armouring	left hand					
c)	c) Calculated diameter of cable	18	28.4	21	16.3	12.2	10.2
	over inner sheath (under armour), mm						
d)	d) Nominal diameter of round armour wire/strip	1.6 4	0.8 4	0.8 4	0.8	1.4	1.4
e)	e) Number of armour wires/strips	Armouring shall be as close as practicable					
f)	f) Short circuit capacity of the armour along for 1 sec-for infoonly	K x A√t (K Amp)(where A = total area of armour in mm^2& t = time in seconds), K=0.091 for Al & 0.05 for steel					
g)	g) DC resistance at 20 oC (Ω/Km)	0.44	2.57	3.38 4	3.99	3.76	4.4
14	Outer Sheath						
a)	a) Material (PVC Type)	ST-1& FR	ST-1& FR	ST-1& FR	ST-1& FR	ST-1& FR	ST-1& FR
b)	b) Calculated diameter under the sheath	21.2	30.1	22.6	17.9	15	13
c)	c) Min. thickness of sheath(mm)	1.4	1.56	1.4	1.4	1.4	1.24
d)	d) Guaranteed value of minimum oxygen index of outer sheath at27oC	Min 29.0	Min 29.0	Min 29.0	Min 29.0	Min 29.0	Min 29.0
e)	e) Guaranteed value of minimumtemperature index at 21 oxygen index	Min 250	Min 250	Min 25 0	Min 250	Min 250	Min 250
f)	f) colour of sheath	Black	Black	Black	Black	Black	Black
15a)	a) Overall diameter of cable	$					
b)	b) Tolerance on overall diameter (mm)	+2/-2 mm					
16	Cable Drums	shall conform to IS 10418 and technical specification					
a)	a) Max./ Standard length per drumfor each size of cable (single	1000/5 0 0	1000/5 0 0	1000/ 5 00	1000/5 0 0	1000/5 0 0	1000/5 0 0

	length) with ±5% Tolerance (mtrs)						
b)	b) Non standard drum lengths	Maximum one(1) non standard lengths of each cable size may be supplied in drums only over & above the standardlengths as specified above.(if required for completion of project)					
17	Whether progressive sequential marking on outer sheath provided	Yes					
18	Identification of cores						
a)	a) colour of cores	Red	R,Y,Bl & Bk	R,Y,Bl& Bk	R,Y,Bl & Bk	R,Y,Bl & Bk	Red & Bk
b)	b) Numbering	N.A	N.A	N.A	N.A	N.A	N.A
19	Whether Cables offered are ISI Marked	YES					
20	Whether Cables offered are suitable for laying as per IS 1255	YES					

$'- As per manufacturer design data

STANDARD TECHNICAL DATA SHEET - 1.1KV KV GRADE PVC CONTROL CABLES

SN	Description	Parameters							
1a	Cable Sizes	2 c x 2.5	3c cx 2.5	5c x 2.5	7 c x 2.5	10 c x 2.5	14 c x 2.5	19 c x 2.5	27 c x 2.5
1b	Manufacturer's type Designation	YWY	YWY	YWY	YWY	YWY	YWY	YWY	YWY
2	Applicable standard	IS: 1554/PT-I/1988 & its referred standards							
3	Rated Voltage(volts)	1100 V grade							
4	Type & Category	FR & C1							
5	Suitable for earthed orunearthed system	for both							
6	Continuous current rating when laid in air ina ambient temp. of 50oCand for maximum conductor temp. of 70 oC of PVC Cables[For information only]	22	19	19	14	12	10.5	9.7	8
7	Rating factors applicableto the current ratings for various conditions ofinstallation:	As per IS-3961-Pt-II-67							
8	Short circuit Capacity								
a)	Short Circuit Amp. (rms)KA for 1 secduration	0.285	0.285	0.285	0.285	0.285	0.285	0.285	0.285
b)	Conductor temp. allowed for the short circuit duty(deg C.)	160^{0}C							
9	Conductor								
a)	Material	Plain annealed High Conductivity stranded Copper (as per IS8130/84)							
b)	Grade	Electrolytic							
c)	Cross Section area (Sq.mm.)	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
d)	Number of wires(No.)	as per Table 2 of IS 8130							
e)	Form of Conductor	Non-compacted Stranded circular shaped conductor							

f)	Direction of lay of stranded layers	Outermost layer shall be R.H lay							
10	Conductor resistance (DC) at 20 oC per km- Maximum	7.41	7.41	7.41	7.41	7.41	7.41	7.41	7.41
11	Insulation								
a)	Composition of Insulation	Extruded PVC type A as per IS-5831-84							
b)	Nominal thickness of	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
	insulation(mm)								
c)	Minimum thickness of Insulation	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.7 1
12	Inner Sheath								
a)	Material	Extruded PVC type ST-I as per IS-5831-84							
b)	Calculated diameter overthe laid up cores,(mm)	7.2	7.8	9.7	10.8	14.4	15.9	18	22. 1
c)	Thickness of Sheath (minimum)mm	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
13	Armour	as per IS 3975/99							
a)	Type and material of armour	Gal. Steel Wire							
b)	Direction of armouring	left hand							
c)	Calculated diameter of cable over inner sheath(under armour), mm	7.8	8.4	10.3	11.4	15	6.5	18.6	22. 7
d)	Nominal diameter of round armour wire/strip	1.4	1.4	1.4	1.4	1.6	1.6	1.6	1.6
e)	Number of armour wires/strips	Armouring shall be as close as practicable							
f)	Short circuit capacity ofthe armour along for 1 sec-for info only	0.05 x A√t (K Amp)(where A = total area of armour in mm2 & t =time in seconds)							
g)	DC resistance at 20 oC(Ω/Km) & Resistivity	As per IS 1554 Part (1), wherever applicable and IS 3975-1999							
14	Outer Sheath								
a)	Material (PVC Type)	ST-1& FR							
b)	Calculated diameter under the sheath	10.6	11.2	13.1	14.2	18.2	19.7	21.8	25. 9
c)	Min.thickness of sheath(mm)	1.24	1.24	1.24	1.24	1.4	1.4	1.4	1.5

									6
d)	Guaranteed value of minimum oxygen indexof outer sheath at 27oC	Min 29.0	Min 29.0	Min 29.0	Min 29.0	Min 29.0	Min 29.0	Min 29.0	Min 29.0
e)	Guaranteed value of minimum temperature index at 21 oxygen index	Min 250	Min 250	Min 250	Min 250	Min 250	Min 250	Min 250	Min 250
f)	colour of sheath	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey
15a)	Overall diameter of cable	$							
b)	Tolerance on overall diameter (mm)	+2/-2 mm							
16	Cable Drums	shall conform to IS 10418 and technical specification							
a)	Max./ Standard length per drum for each size ofcable (single length) with ±5% Tolerance (mtrs)	1000/500							
b)	Non standard drumlengths	Maximum one(1) non standard lengths of each cable size may besupplied in drums only over & above the standard lengths as specified above.(if required for completion of project)							
17	Whether progressive sequential marking onouter sheath provided								
18	Identification of cores	Yes							
a)	colour of cores	R & Bk	R, Y & Bl	Red R,Y,Bl	Grey	Grey	Grey	Grey	Grey
b)	Numbering	N.A	N.A	N.A	Numerals in black ink				
19	Whether Cables offeredare ISI marked	YES							
20	Whether Cables offered are suitable for laying asper IS 1255	YES							

$'- As per manufacturer design data

ANNEXURE - K

Technical Specification of Oil BDV Test Set (Applicable as per BPS)

Item	Specification
Functional Requirement	1. The instrument should be suitable for Automatic Measurement of Electrical Breakdown Strength of Reactor oil as per relevant standards. 2. The test results should have repeatability, consistency in laboratory condition.
Test Output	0-100 kV (Rate of rise: 0.5 to 5KV/Sec)
Accuracy	± 1 Kv
Resolution	0.1 KV
Switch off Time	≤ 1ms
Display/Control	LCD/Keypads.
Printer	Inbuilt/External
Measurement Programmes	Fully Automatic Pre-programmed/User programmed Test Sequences including as per latest IEC & other national/international standards.
Test Lead /Accessories	One complete set of electrodes, gauge etc. compatible with the instruments should be provided for successfully carrying out the test in EMPLYER S/S. Additionally all the required accessories, tools, drawing, documents should be provided for the smooth functioning of kit. Further hard carrying case (which should be robust/ rugged enough) for ensuring proper safety of the kit during transportation shall have to be provided.
Design/Engg.	The complete equipment along with complete accessories must be designed / engineered by Original Equipment Manufacturer.
Power Supply	It shall work on input supply variations, V: 230 ±10 %, f: 50 Hz ±5 % on standard sockets.
Operating Temperature	0 to +50 deg C
Relative humidity	Max. 90% non-condensing.
Protection/Control	Against short circuit, over load, transient surges etc. Also the instrument should have facility of stopping automatically on power failure. Also the kit should have facility of HV chamber interlocking as well as zero start interlocking.
Environment	The test kit shall be compatible for EMI/EMC/Safety environment requirement as per IEC.
Guarantee	Warranty/Guarantee Period: Min 05 year from the date of successful & complete commissioning at Emplyer sub-station. All the materials, including accessories, cables, laptops etc. are to be covered under warranty/guaranty period. If the kit needs to be shifted to supplier's works for repairs within warranty/guaranty period, suppliers will have to bear the cost of spares, software, transportation of kit for repair at test lab / works.
Calibration Certificate	Unit shall be duly calibrated before supply and the date of calibration shall not be older than two month from the date of supply of Kit.

Training	Supplier shall have to ensure that the instrument is made user friendly. Apart from the detailed demonstration at site, the supplier shall also have to arrangenecessary training to EMPLYER engineers.
Commissioning, handing over the Instrument	Successful bidder will have to commission the instrument to the satisfaction ofEMPLOYER. The instrument failed during the demonstration shall be rejected and no repairs are allowed.
After sales service	Bidder will have to submit the documentary evidence of having established mechanism in India for prompt services.

Technical Specification of Portable Dissolved Gas Analysis of Oil (Applicable as per BPS)

S.No.	Particulars	Specification
01	Functional Requirement	The Portable DGA equipment to extract, detect, analyze and display the dissolved gases in insulating oil as specified in IEEE C 57-104-2008 andIEC 60599-2007.
02	Detection ofGases	All the fault gases i.e. H_2, CH_4, C_2H_2, C_2H_4, C_2H_6, CO & CO_2 concentrations shall be individually measured and displayed. The minimum detection limits of the instrument for the above gases shall strictly be met the requirement of IEC-60567-2011-Page No. 47-clause9.2, table-5.
03	Power Supply	It shall be operated with AC single phase,50 Hz +/-5%, 230 V +/- 10%supply. All power cable and necessary adaptors shall be provided by supplier.
05	Instrument controland Data handling, Internal Memory	a) Instrument shall be having in-built control for all the functions (data acquisitions and data storage), it shall have a facility for communication with computer for downloading the data from instrument via USB port. b) Laptop shall be provided for communication with the instrument. it shall be of latest specification along with licensed preloaded OS and software as well as software for interpreting DGA results accordance with IEEE C 57-104-1991 and IEC 60559-1999. Laptop carrying caseshall also be provided. c) Internal Memory can capable of store atleast 15000 records
06	General Conditions	a) Performance Parameters like - Minimum Detection Limits, Working Range, Accuracy, repeatability etc. shall be finalized during detailed engineering. b) The portable DGA equipment supplier shall demonstrate during commissioning of the kit that the results shown by the kit are within the specified accuracy and repeatability range and EMPLOYER will provide only the insulating oil/ GAS-IN-OIL standard for testing. c) All required items/instruments /spares /consumable /connectingcables/communication cables/instruments/manuals/Certificates/training materials/originalsoftware/original licensed data/station operating software/educationCD/DVDs that are essential to understand and operate the instrumentshall be supplied at

		no extra cost.
07	Operating Temperature, Relative humidity	01. Temperature 0-50 Deg. C 02. 85% non-condensing
	& Dimensions	03. Portable
08	Warranty	The entire test set up shall be covered on warranty for a period of 5 year from the last date of complete commissioning and taking over the test set up. If the kit needs to be shifted to suppliers works for repairs, supplier will have to bear the cost of, spares, software, transportation etc of kit for repair at test lab/works.
09	Service Support	The supplier shall furnish the requisite documents ensuring that the equipment manufacturer is having adequate service team and facility in India to take care of any issues during operation of the instrument.
10	Training	The supplier shall provide adequate training for a period of two workingdays pertaining to the operation and troubleshooting to site personnel.

ANNEXURE - L

ONLINE DISSOLVED GAS (MULTI-GAS) AND MOISTURE ANALYSER (APPLICABLE AS PER BPS)

1.1. Online Dissolved Gas (Multi-gas) and Moisture Analyser along with all required accessories including inbuilt display shall be provided with each reactor for measurement & analysis of dissolved gases and moisture in the oil. Interpretations shall be as per IEC 60599-1999.

1.2. The equipment shall detect, measure and analyse the following gases:

Gases & Moisture Parameters	Typical Detection Range
H_2	5 – 5,000 ppm
CH_4	5 – 5,000 ppm
C_2H_6	5 – 5,000 ppm
C_2H_4	3 – 5,000 ppm
C_2H_2	1 – 3,000 ppm
CO	10 – 10,000 ppm
CO_2	20 – 30,000 ppm
H_2O	2 – 100 % RS should have facility for measurement of moisture in oil in ppm

1.3. The analyser should measure (not calculate) all above gases and should have 100% sensitivity. The equipment shall be capable of transferring data to sub-station automation system confirming to IEC 61850. Necessary interface arrangement shall be provided by the contractor for integration with automation system. The necessary type test report for such confirmation shall be submitted during detailed engineering.

1.4. Equipment shall have facility to give SMS alert to at least three users whenever any fault gas violates the predefined limit.

1.5. Equipment should work on station auxiliary supply. In case other supply is required for the equipment then suitable converter shall be included. All the necessary power and control cables, communication cables, cable accessories as required shall beprovided by the supplier.

1.6. Online DGA shall be installed out door on reactor in harsh ambient and noisy condition (Electromagnetic induction, Corona, and capacitive coupling). Equipment shall be mounted separately on ground. Suitable arrangement shall be provided to support and protect the inlet and outlet piping arrangement. The connecting oil lines must be of Stainless Steel rigid pipes or flexible hoses. The equipment shall be suitable for proper operation in EHV substation (800kV) environment where switching takes place in the EHV/HV System. The suitable indications for power On, Alarm, Caution, normal operation etc. shall be provided on the front panel of the equipment. The equipment shall have IP55 Stainless Steel enclosure, suitable for 55 ^{0}C ambient temperature and

EMI and EMC compatibility. The Equipment must carry a minimum of five (5) years manufacturer's Warranty.

1.7. The equipment shall display all the individual gas and moisture concentration on its display unit and shall have facility to download all the stored the data from the unit forfurther analysis. The sampling rate shall be selectable as 2 or 4 or 6 or 12 hours etc. The equipment shall have inbuilt memory to store these results for complete one year even if sampling is done at the lowest interval. The carrier and calibration gas (if applicable) shall have minimum capacity to work for at least three years without replacement. All the consumable (if any) upto warrantee period shall be included inthe scope of supply

1.8. The Equipment must have an automatic Calibration facility at fixed intervals. For calibration if anything required including cylinder must be mounted with the Equipment.

1.9. The technical feature of the equipment shall be as under:

Accuracy	$\pm$ 10%
Repeatability	$\pm$3% to 10% depending upon gases
Oil temperature range	- 20^0 C to + 120^0 C
External Temp. Range	- 20^0 C to + 55^0 C (External temp range of 55^0 C is important and should not be compromise due to Indian ambient & operating conditions.)
Humidity range	10 to 95 %
Operating Voltage	230 Vac; 50 Hz (±20% variation)
Communications	USB&IEC 61850 compliant

1.10. Software for fault indication and fault diagnostics shall include following:Fault indication:

i) IEEE, IEC or user configurable levels of dissolved gases
ii) Rate of change

trendingFault Diagnosis:

i) Key gases
ii) Ratios (Rogers, IEC. etc.)
iii) Duval's Triangle

1.11. The equipment shall be supplied with all necessary accessories required for carrying out DGA of oil sample complete in all respect as per the technical specification. The following shall be also form a part of supply.

i) Software
ii) Operation Manual (2 set for every unit),
iii) Software Manual and
iv) Compact disc giving operation procedures of Maintenance Manual &Trouble shooting instructions.

1.12. The installation and commissioning at site shall be done under the supervision ofOEM representative or OEM certified representative.

ANNEXURE - M

On Line Dissolved Hydrogen and Moisture Monitor (Applicable as per BPS)

1.0 Online Dissolved Hydrogen and Moisture Analyser along with all required accessories including inbuilt display shall be provided with each Reactor for measurement & analysis of dissolved gases and moisture in the oil. Interpretations shall be as per IEC 60599-1999

2.0 The equipment shall be capable of transferring data to sub-station automation system confirming to IEC 61850. Necessary interface arrangement shall be provided by the contractor for integration with automation system. The necessary type test report for such confirmation shall be submitted during detailed engineering

3.0 Equipment should work on station auxiliary supply. In case other supply is required for the equipment then suitable converter shall be included. All the necessary power and control cables, communication cables, cable accessories as required shall be provided by the supplier

4.0 Equipment shall be installed out door on reactor in harsh ambient and noisy condition (Electromagnetic induction, Corona, and capacitive coupling). Equipment shall be mounted separately on ground. Suitable arrangement shall be provided to support and protect the inlet and outlet piping arrangement. The connecting oil lines must be of Stainless-Steel rigid pipes or flexible hoses. The equipment shall be suitable for proper operation in EHV substation (800kV) environment where switching takes place in the EHV/HV System. The suitable indications for power On, Alarm, Caution, normal operation etc. shall be provided on the front panel of the equipment. The equipment shall have IP55 Stainless Steel enclosure, suitable for 55 ^{0}C ambient temperature and EMI and EMC compatibility. The Equipment must carry a minimum of five (5) years manufacturer's Warranty

5.0 The equipment shall display H_2 and moisture concentration on its display unit and shall have facility to download all the stored the data from the unit for further analysis. The sampling rate shall be selectable as 2 or 4 or 6 or 12 hours etc. The equipment shall have inbuilt memory to store these results for complete one year even if sampling is done at the lowest interval. All the consumable (if any) upto warrantee period shall be included in the scope of supply

6.0 The monitor shall also be suitable to detect Water Content measured in ppm or % RS (Relative Saturation). The sensors shall be able to withstand pressure from vacuum to 10psi.

7.0 Technical Parameters:

Sr. No.	Parameters	Requirements
a)	The measurement range / Output:	
	Hydrogen Dissolved in oil	0 to 2000 ppm, with 4 – 20 mA Output
	Water Dissolved in oil	0 to 95% RS, with 4 – 20 mA output

b)	Alarms/Indication (High & Very High)	
	Hydrogen	Programmable NO/NC contacts,
	Water	Programmable NO/NC contacts,
c)	Environment	
	Operating Ambient Temperature	– 20 to + 55 deg C

	Operating Oil Temperature	– 20 to + 105 deg C
d)	Pressure Withstand, (Oil side)	Full Vacuum to 10 psi.
e)	Communications	USB&IEC 61850 compliant

Equipment shall be mounted separately to avoid effect of vibration. Suitable arrangement shall beprovided support and protect the inlet and outlet piping arrangement.

8.0 Software for fault indication and fault diagnostics shall include following:Fault indication:

iii) IEEE, IEC or user configurable levels of dissolved gases
iv) Rate of change trending

9.0 The equipment shall be supplied with all necessary accessories required for carrying out DGA of oil sample complete in all respect as per the technical specification. The following shall be also form a part of supply.

v) Software
vi) Operation Manual (2 set for every unit),
vii) Software Manual and
viii) Compact disc giving operation procedures of Maintenance Manual &Trouble shooting instructions.

10.0 The installation and commissioning at site shall be done under the supervision of OEM representative or OEM certified representative.

ANNEXURE - N

On-line insulating oil drying system (Cartridge type) (if specified in BPS)

In addition to provision of air cell in conservators for sealing of the oil system against the atmosphere, each reactor shall be provided with an on line insulating oil drying system of adequate rating with proven field performance. This system shall be separately ground mounted and shall be housed in metallic (stainless steel) enclosure. The bidder shall submit the mounting arrangement. This on line insulating oil drying system shall be

i. Designed for very slow removal of moisture that may enter the oil system or generated during cellulose decomposition. Oil flow to the equipment shall be controlled through pump of suitable capacity (at least 5 LPM).

ii. The equipment shall display the moisture content in oil (PPM) of the inlet and outlet oil from the drying system.

iii. In case, drying system is transported without oil, the same shall be suitable for withstanding vacuum to ensure that no air / contamination is trapped during commissioning.

In case, drying system is transported with oil, the oil shall conform to EMPLOYER specification for unused oil. Before installation at site, oil sample shall be tested to avoid contamination of main tank oil.

iv. Minimum capacity of moisture extraction shall be 10 Litres before replacement of cartridge. Calculation to prove the adequacy of sizing of the on line insulating oil-drying system along with make and model shall be submitted for approval of purchaser during detail engineering.

v. The installation and commissioning at site shall be done under the supervision of OEM representative or OEM certified representative.

vi. The equipment shall be capable of transferring data to substation automation system confirming to IEC 61850 through FO port. Necessary interface arrangement shall be provided by the contractor for integration with automation system.

The equipment shall be supplied with Operation Manual (2 set for every unit), Software (if any), and Compact disc giving operation procedures of Maintenance Manual & Trouble shooting instructions.

ANNEXURE - O

Nitrogen Injection Type Fire Prevention & Extinguishing System

1.1 Nitrogen Injection Type Fire Protection System (NIFPS) shall be designed to preventexplosion of transformer/reactor tank and the fire during internal faults resulting from arc.

The system shall work on the principle of Drain & stir. On activation, it shall drain a pre- determined quantity of oil from the tank top through drain valve to reduce the tank pressure, isolate conservator tank oil and inject nitrogen gas at high pressure from the bottom side of the tank through inlet valves to create stirring action and reduce the temperature of oil below flash point to extinguish the fire. On operation, the quantity of oil removed from the tank shall be such that adequate amount of oil shall remain to cover active part (i.e. core coil assembly).

Electrical isolation of transformer/reactor shall be an essential pre-condition for activating the system.

1.2 Operational Controls

The system operation shall be fully automatic and activate from the required fire and other trip signals. In addition to automatic operation, remote operation from control room/ remote centre and local manual control in the fire extinguishing cubicle shall also be provided. System shall operate on following situations:

1.2.1 Prevention of transformer/reactor from explosion and fire

To prevent transformer/reactor from explosion and fire in case of an internal fault, signals given by operation of Electrical protection relays and tripping of circuit breaker of transformer/reactor and operation of either Buchholz relay or pressure relief valve (PRV) shall be used to activate the system. The exact logic for system activation shall be finalized during detailed engineering.

1.2.2 Prevention of transformer/reactor from fire

In case of fire, sensed by fire detectors, the system shall be activated only after electrical isolation of the transformer/reactor, confirmed by breaker trip. If the fire detection is not associated with any other fault, the system activation shall be only manual. Manual operation switch shall be provided in the control room with a cover to avoid accidental operation of it.

1.3 Operation of System

On receiving activation signal, the following shall take place:

i) Open the quick opening drain valve to drain the top layer oil

ii) Shut off the conservator isolation valve to prevent flow of oil from theConservator tank to the main tank

iii) Open the Nitrogen regulator valve to inject Nitrogen into the transformer/reactortank to create stirring of oil. There shall be interlock to prevent activation of the system if the transformer/reactor is not electrically isolated.

There shall also be provision for isolating the system during maintenance and/or testing of the transformer/reactor.

1.4 Technical Particulars

The contractor shall be responsible for the design of the complete system and shall submit the drawings and design calculations for the number of fire detectors, pipe sizing of drain pipe and Nitrogen injection pipe, Nitrogen cylinder capacity, number of injection points, etc. and get approval from EMPLOYER.

Facility shall be provided to test the system when the transformer/reactor is in service, without actually draining the oil and injecting Nitrogen.

The Nitrogen regulator valve shall be designed in such a way that the Nitrogen shall not enter the transformer/reactor tank even in case of passing/ leakage of valve.

Owner shall provide two distinct station auxiliary DC feeders for control purposes. The system shall work on station DC supply with voltage variation defined in GTR. The control box of fire protection system shall have facility to receive these feeders for auto changeover of supply. It shall be the contractor’s responsibility to further distribute power to the required locations. In case auxiliary DC power supply requirement is different than station auxiliary DC supply, then all necessary DC-DC converters shall be provided by the Contractor.

Following minimum indications and alarms shall be provided in the local cubicle as well as in the control box: -

- Nitrogen cylinder pressure indication - manometer with sufficient number ofadjustable NO contacts
- Nitrogen cylinder pressure low
- Fire in Transformer/ Reactor
- Oil drain started
- Conservator oil isolation valve closed
- Nitrogen injection started
- DC supply fail
- Oil drain valve closed
- Gas inlet valve closed

1.5 Details of Supply of System Equipments and Other Related Activities:

The scope of supply shall include the following items and any other items required for safe and trouble-free operation of the system.

i) Fire extinguishing cubicle with base frame and containing at least the following:

- Nitrogen gas cylinder of sufficient capacity with pressure regulator andmanometer with sufficient number of adjustable NO contacts.

- Oil Drain Assembly including oil drain pipe extension of suitable size forconnecting pipes to oil pit
- Mechanical release device for oil drain and nitrogen release
- Limit switches for monitoring of the systems
- Panel lighting
- Flanges on top of the panel for connecting oil drain and nitrogen injectionpipes for transformer/reactor
- Back up pressure switch to operate nitrogen gas valve
- Pressure indicators for Nitrogen pressure of the cylinder and actual injectionthrough Nitrogen regulator

ii) Control box to be installed in the control room of the station for monitoring system operation, automatic control and remote operation, with alarms, indications, switches, push buttons, audio signal, suitable for tripping and signalling.

iii) Required number of fire detectors to be located in strategic locations to be finalized during detailed engineering.

iv) All controls, alarms, panels, cables, cable trays (if required), junction boxes etc.

1.6 Under Ground Oil Storage Tank

Each transformer/reactor unit shall be provided with an underground oil storage tank. The oil storage tank shall have Non Corrosive, water proof, epoxy coated (from Inside) mild steel (minimum thickness 6 mm) to store drained out oil on operation of NIFPS. The tank shall be painted from outside as per **Annexure – F**. The total capacity of storage tank shall be atleast 10% of transformer/reactor tank oil to avoid overflowing of oil considering that drained oil volume shall be around 10% of transformer/reactor tank oil. Necessary arrangement shall be made on underground storage tank so as to take out the drained oil from the tank for further processing and use. All the pipe and physical connection from transformer/reactor to oil pit shall be in the scope of contractor.

This storage tank shall be placed in the pit made of brick walls with PCC (1:2:4) flooring with suitable cover plates to avoid ingress of rain water. The design of tank and pit shall be finalised during detailed engineering.

1.7 Installation and pre-commissioning test

After installation the system pre-commissioning tests shall be carried out jointly with the Owner’s representative before the system is put in service.

ANNEXURE - P

Oil sampling bottles (Applicable as per BPS)

Oil sampling bottles (if specified in BPS) shall be suitable for collecting oil samples from Reactors 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.

Oil sampling bottles shall be made of stainless steel having a capacity of 1litre. Oil Sampling bottles shall be capable of being sealed gas-tight and shall be fitted with cocks on both ends.

The design of bottle & seal shall be such that loss of hydrogen shall not exceed 5% per week.
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.

The scope of oil sampling bottles shall be included in the bid price as per the quantity indicated in the bid price schedule.

3.6 OIL SYRINGE (APPLICABLE AS PER BPS)

If specified in BPS, the glass syringe of capacity 50ml (approx) and three way stop cock valve shall be supplied. The syringe shall be made from Heat resistant borosilicate Glass. The material and construction should be resistant to breakage from shock and sudden temperature changes, reinforced at luer lock tip Centre and barrel base.

The cylinder-Plunger fitting shall be leak proof and shall meet the requirement of IEC-60567. Plunger shall be grounded and fitted to barrel for smooth movement with no back flow. Barrel rim should be flat on both sides to prevent rolling and should be wide enough for convenient finger tip grip. The syringe shall be custom fit and uniquely numbered for matching. The syringe shall be clearly marked with graduations of 2.0 ml and 10.0 ml and shall be permanently fused for life time legibility.

ANNEXURE - Q

Oil Storage Tank (Applicable as per BPS)

1. Oil storage tank shall be of minimum capacity (as per BPS) along with complete accessories. The oil storage tank shall be designed and fabricated as per relevant Indian Standards e.g., IS: 803 or other internationally acceptable standards. Reactor oil storage tanks shall be **towable on pneumatic tyres** and rested on manual screw jacks of adequate quantity & size. The tank shall be cylindrical in shape and mounted horizontally and made of mild steel plate of adequate thickness. Diameter of the tank shall be 2.0 meter approximately. The tank shall be designed for storage of oil at a temperature of 100C.

2. The maximum height of any part of the complete assembly of the storage tank shall not exceed 4.0 metres above road top.

3. The tank shall have adequate number of jacking pad so that it can be kept on jack while completely filled with oil. The tank shall be provided with suitable saddles so that tankcan be rested on ground after removing the pneumatic tyres.

4. The tank shall also be fitted with manhole, outside & inside access ladder, silica gel breather assembly, inlet & outlet valve, oil sampling valve with suitable adopter, oil drainage valve, air vent etc. Pulling hook on both ends of the tank shall be provided sothat the tank can be pulled from either end while completely filled with oil. The engine capacity in horse power to pull one tank completely fitted with oil shall be indicated. Oil level indicator shall be provided with calibration in terms of litre so that at any time operator can have an idea of oil in the tank. Solenoid valve (Electro-mechanically operated) with Centrifugal pump shall be provided at bottom inlet so that pump shall be utilised both ways during oil fill up and draining. Suitable arrangement shall also be provided to prevent overflow and drain form the tank.

5. The following accessories shall also form part of supply along with each Oil storage tank.

5.1 Four numbers of 50NB suitable rubber hoses for Reactor oil application up to temperature of 100C, full vacuum and pressure up to 2.5 Kg/ cm2 with couplers and unions each not less than 10 metre long shall be provided.

5.2 Two numbers of 100NB suitable for full vacuum without collapsing and kinking vacuum hoses with couplers and unions each not less than 10 metre long shall also be provided.

5.3 One number of digital vacuum gauge with sensor capable of reading up to 0.001 torr, operating on 240V 50Hz AC supply shall be supplied. Couplers and unions for sensor should block oil flow in the sensor. Sensor shall be provided with at-least 8 meter cable soas to suitably place the Vacuum gauge at ground level.

5.4 The painting of oil storage tank and its control panel shall be as per technical specification.

5.5 The tank shall contain a self mounted centrifugal oil pump with inlet and outlet valves, with couplers -suitable for flexible rubber hoses and necessary switchgear for its control. There shall be no rigid connection to the pump. The pump shall be electric motor driven, and shall have a discharge of not less than 6.0 kl/hr. with a discharge head of 8.0m. The pump motor and the control cabinet shall be enclosed in a cubicle with IP-55 enclosure.

ANNEXURE - R

Automatic Mulsifire System (or High Velocity Water Spray System)

1. Description:

This system is widely used for firefighting of outdoor Reactors. Spray type fire protection essentially consists of a network of projectors and an array of heat detectors used to sense high temperature near the Reactor to be protected. If the temperature exceeds the set value, the automatic mulsifire system sprays water at high pressure through a Deluge valve from the pipe network laid for this system. Fire detectors located at various strategic points are on the surface of the transformer to control fire on any burning oil spilled over.

1.1 Subsystems used to make a complete mulsifire system:

a) Main Hydrant
This is used to carry the water to various parts of the switchyard or transformer substation and forms the backbone of the system. Sturdy corrosion-free pipes and valves are used for this purpose. The materials should be able to withstand fire for a reasonable duration.

b) Fire Detector
Fire detectors can either be thermocouples or specially designed bulbs which burst when they experience a high temperature and release any valves or checking device to start the water supply.

c) Ring Mains and Nozzles
Ring mains, which surround the transformer are provided to feed the water to the nozzles at various levels. Since the water pressure is high, the ring mains should be designed to withstand this pressure. Nozzles should be located such that the water spray, in the event of a fire, envelopes the entire surface of the transformer. The whole system should be periodically checked to detect any leakages.

d) Pumps
Pumps are provided to fill the hydrants initially and to maintain its pressure. Pumps driven by electrical motors are a standard provision; however, the standby pumps should preferably be diesel engine driven. It is recommended that the main and standby pumps in a pump house be segregated.

1.2 Electrical Safety

As per IEEMA specification, from safety considerations, the following electrical clearances are recommended between the mulsifier system pipe work and live parts of the reactor to be protected.

- 420 kV bushing 3500 mm
- 245 kV bushing 2150 mm
- 145 kV bushing 1300 mm
- 52 kV bushing 630 mm
- 36 kV bushing 320 mm

1.3 Installation Care

- Deluge Valve shall be water pressure operated manual reset type.
- Each Deluge valve shall be provided with a local panel from which will enable manual electrical operation of the valve.
- In addition to this, each valve shall be provided with local operation latch.
- Test valves shall simulate the operation of Deluge valves and shall be of quick opening type.

ANNEXURE - S

Rating Pate of Reactor

Manufacturer's name, country and city where the reactor was assembled					
MVAR Rating, Voltage & Type of Reactor (for example 80MVAR, 420kVLine reactor with NGR / bus reactor)					
Type of Cooling			Applicable Standard		
Rated Power at rated voltage	MVAR		Rated frequency	Hz	
Frequency Withstand Voltage)	kV		Number of phases		
HV end/ terminal	kVp/ kVp/ kVrms		Copper Mass	Kg	
Neutral	kVp/ kVp/ kVrms		Core & Coil Mass	Kg	

Guaranteed Temperature rise over ambient temperature of 50 Deg. C					
(a) Top Oil					
(b) Winding					
Vacuum withstand Capability of tank					
Noise level					
Tan delta of winding					
Moisture content					
Manufacturer's Serial Number					
Year of manufacture					
Work Order No.					
Purchaser's Order No. & Date					
OGA Drg. No.					
Rated Voltage					
Maximum operating Voltage	kV		% Impedance	%	
Rated Current	A		Zero sequence reactance	Ohm	
Winding connection			Ratio of zero sequence reactance to positive sequence reactance (X0/X1)		
Reactance at rated voltage & frequency	ohms		Vibration and tank stress	Micron & kg/sq. mm	

Basic Insulation Level(Lightening Impulse/Switching Impulse/Power			Core mass	Kg	

CHAPTER 22: TECHNICAL SPECIFICATION FOR 132KV, 66kV & 33KV CIRCUIT BREAKER (AIS)

22.1.0. SCOPE

22.1.1. The intention of this Section of the Specification is to cover design, manufacture, testing at manufacturer's works and of 132kV, 66kV and 33 KV Circuit Breakers with all fittings and accessories including mounting structures as specified hereunder.

22.2.0. GENERAL REQUIREMENTS

22.2.1. The circuit breaker shall be of three phase unit (gang operated) (or) three identical single-phaseunits (as said in data sheet), outdoor**, SF6 gas filled** single pressure puffer type(132kV and 66kV)and VCB for 33kV. The operating mechanism shall be electrically and mechanically trip/free with anti-pumping facility suitable for remote electrical closing, tripping as well as local Operation facility as specified. The CBs are meant for installation with Transformers & **Lines and capacitor banks as applicable.**

22.2.2. The circuit breaker shall be capable of 3-ph auto-reclosing.

22.2.3. The circuit breaker shall be so designed to withstand the effects of temperature, wind load, short circuit, **seismic conditions** and other adverse conditions.

22.2.4. The circuit breaker shall be capable of switching transformer magnetizing currents and shall be restrike - free.

22.2.5. All similar parts, particularly removable ones, shall be interchangeable with one another.

22.2.6. All cable ferrules, lugs, tags, etc. required for cabling from equipment control cabinet/operating mechanism to the central control cabinet of the breaker shall be supplied loose as per approved schematics.

22.2.7. The SF6 breaker shall be designed to ensure that condensation of moisture is controlled **by proper selection of organic insulating materials having low moisture absorbing characteristics**

22.2.8. The support structure of circuit breaker shall be hot dip galvanised. Sufficient galvanising thickness shall be achieved with **900 gm/m² (130 micron).** All other parts shall be painted as per painting specification enclosed separately.

22.2.9. All mechanical parts and linkages shall be robust in construction and maintenance free over at least 10,000 switching operations except for lubrication of pins/articulated joints at 5000 operations **and electrical E2 performance**.

22.3.0. OPERATING MECHANISM

22.3.1. A power spring operated mechanism for closing and tripping shall be provided in the breaker control cabinet. This device shall be so interlocked that while it is under maintenance, the breaker cannot be operated from remote. A slow acting, manually operated device shall be provided for inspection and maintenance purposes.

22.3.2. Circuit breaker operating mechanism shall be capable of storing energy for at least two complete closing and tripping operations.

22.3.3. Each mechanism shall have an operation counter.

22.3.4. The operating mechanism shall be trip-free and mounted and enclosed in a weather-proof, vermin-proof, sheet steel cabinet conforming to IP: 55 degree of protection. Sheet steel thickness shall be as specified in data sheet. The cabinet shall also house relays, control and auxiliary equipment of each breaker and provision for terminating all control, alarm and auxiliary circuits. It shall be provided with hinged doors with provision for locking and removable gland plates to be drilled at site. Inspection window shall be provided for observation of the instruments without opening the cabinet. It shall be mounted so as to provide convenient access from ground level. **Two trip coils shall be provided.**

22.3.5. The cabinet shall be fitted with a thermostatically controlled anti-condensation heater, a 15A, 1 phase, 5 pin socket outlets with switch and a cubicle illuminating lamp suitable for operation on 240 V AC 50Hz supply.

22.3.6. Circuit breakers shall feature high repeatability of absolute closing time over a wide range of parameters (ambient temperature, pneumatic pressure, control voltages, etc).

22.3.7. Main poles shall operate simultaneously. There shall be no objectionable rebound and the mechanism shall not require any critical adjustment. It shall be strong, rigid, positive and fast in operation.

22.3.8. **Pole discrepancy** shall be provided which shall detect pole position discrepancy.

22.3.9. The design of the circuit breaker shall be such that contacts will not close automatically upon loss of gas/ air pressure.

22.3.10. Closing release shall be capable of operating within the range of the rated voltage as specified in the data sheet. Shunt trip shall operate satisfactorily under all operating conditions of the circuit breaker up to the rated breaking capacity of the circuit breaker within the range of the rated voltages specified in the Data sheet.

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

22.3.12. All controls, gauges, relays, valves, hard drawn copper piping and all other accessories as necessary shall be provided including the following:

22.3.13. Low pressure alarm and lock out relay with adjustable pressure setting suitable for operation on DC system

22.3.14. A no-volt relay for remote indication of power failure for compressor motor/ Spring Charge motor.

22.3.15. As long as power is available to the motor, continuous sequence of closing and opening operations shall be possible.

22.3.16. After failure of power supply to the motor, at least **two close-open** operation of the circuit breaker shall be possible from stored energy.

22.3.17. Spring charging motor shall be standard single phase universal motor suitable for 220 volts supply for Rangia GIS and 110volts for Nalbari GSS.

22.3.18. Motor rating shall be such that it requires only about 30 seconds for full charging of the closing spring.

22.3.19. Closing action of the circuit breaker shall compress the opening spring ready for tripping.

22.3.20. During closing, springs are discharged and after closing of breaker, springs shall automatically be charged for the next operation. Facility for manual charging of closing springs shall be provided. Mechanical interlocks shall be provided in the operating mechanism to prevent discharging of closing springs when the breaker is already in the closed position.

22.4.0. OPERATING MECHANISM CONTROL

22.4.1. The breaker shall normally be operated by remote electrical control. However, provision shall be made for local electrical control. For this purpose, a local/remote selector switch, close and trip control switch/push button shall be provided in the breaker central control cabinet.

22.4.2. Two electrically independent trip circuit including two trip coils per breaker shall be operated from two separate DC sources. First trip coil shall be utilized for tripping the breaker on main protection fault detection. Whereas second trip coil shall be used to trip the breaker when first trip coil fails to trip the breaker and backup protection comes into operation and shall also be used to trip the breaker on command.

22.4.3. The trip coils shal be suitable for trip circuit supervision during both **open and close position** of the breaker. Necessary terminals shall be provided in the central control cabinet of the circuit breaker by the supplier.

22.4.4. The auxiliary switch with **12NO+12NC** contacts of the breaker shall be positively driven by the breaker operating rod.

22.4.5. A conveniently located manual tripping lever or button shall also be provided for local tripping of the breaker and simultaneously opening the reclosing circuit. A local manual closing device which can be easily operated by one man standing on the ground shall also be provided for maintenance purpose. Direction of motion of handle shall be clearly marked.

22.4.6. When the spring get fully charged either through motor or hand cranking, the spring charging motor and the hand cranking **suitable mechanical and electrical indication shall be provided for same. On restoration of electrical supply the mechanical handle shall be automatically disengaged.**

22.5.0. SF6 GAS SYSTEM

22.5.1. SF6 gas shall serve as an arc-quenching medium during opening/closing operation and as an insulating medium between open contacts of the circuit breaker.

22.5.2. The circuit breaker shall be single pressure **puffer** 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.

22.5.3. All gasketed surfaces shall be smooth, straight and reinforced, if necessary, to minimise 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 1% per year

22.5.4. In the interrupter assembly there shall be an absorbing product box to minimise the effect of SF6 decomposition products and moisture. The material used in the construction of the circuit breakers shall be such as fully compatible with SF6 gas decomposition products.

22.5.5. Each pole shall form an enclosure filled with SF6 gas independent of two other poles (145 and 66 kV CBs) and the SF6 density of each pole shall be monitored.

22.5.6. 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:

- 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.

22.5.7: SF6 gas shall be as per IEC 60376

22.6.0. VACUUM INTERRUPTER ASSEMBLY

22.6.1. Each pole of the circuit breaker shall be provided with vacuum interrupter, one for each phase, hermetically sealed for life and encapsulated by ceramic insulators. The interrupter shall be provided with steel chromium arc chamber to prevent vaporized contact material being deposited on the insulating body. A further shield giving protection to the metal bellows shall also follow the travel of the moving contacts to seal the interrupter against the surroundings atmosphere.

22.6.2. It shall have high and consistent dielectric strength of vacuum unaffected by environment and switching operations. Bronzed joints should ensure retention of vacuum for life time. It shall have low and stable contact resistance due to absence of oxidation effects and shall ensure low power loss. The arcing voltage shall be low and minimum contact erosion

22.7.0. BUSHINGS AND INSULATORS

22.7.1. Bushings and Insulators shall be of Porcelain, Solid core type. Porcelain used for the manufacture of bushings and insulators shall be homogeneous, free from defects, cavities and other flaws or imperfections that might affect the mechanical or dielectric quality and shall be thoroughly vitrified, tough and impervious to moisture.

22.7.2. Glazing of the porcelain shall be of uniform brown colour, free from blisters, burns and other similar defects. Bushings shall be designed to have sufficient mechanical strength and rigidity for the conditions under which they will be used. All bushings of identical ratings shall be interchangeable.

22.7.3. Puncture strength of bushings shall be greater than the dry flashover value. When operating at normal 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 bushings when operating at the normal rated voltage.

22.7.4. Bushings shall satisfactorily withstand the insulation level specified in data sheet.

22.8.0. FIXED AND MOVING CONTACTS

22.8.1. Main contacts shall have ample area and contact pressure for carrying the rated current and the short time rated current of the breaker without excessive temperature rise which may cause pitting or welding. Contacts shall be adjustable to allow for wear, easily replaceable and shall have minimum moving parts and adjustments to accomplish these results. Main contacts shall be the first to open and the last to close so that there will be little contact burning and wear out.

22.8.2. Arcing contacts, if provided, shall be the first to close and the last to open and shall be easily accessible for inspection and replacement. Tips of arcing and main contacts shall be silver faced.

22.8.3. If multi-break interrupters are used, they shall be so designed and augmented that a fairly uniform voltage distribution is developed across them.

22.9.0. INTERLOCKS

22.9.1. Key release mechanical interlocks shall be incorporated in the operating mechanism for interlocking with the associated isolators, so that operation of the circuit breaker is dependent on a "key-trapped" situation. In addition, electrical interlocks with associated isolators shall be provided.

22.10.0. ADDITIONAL DUTY REQUIREMENTS

22.10.1. Circuit breakers shall be capable of clearing short line faults with the same impedance behind the bus corresponding to the rated fault current.

22.10.2. Circuit breakers shall be capable of breaking 25% of rated fault current at twice rated voltage under out of phase conditions.

22.10.3. The Bid shall highlight the design features provided to effectively deal with:

a) Breaking of inductive currents and capacitive currents.

b) Charging of long lines and cables.

c) Clearing developing faults within the full rating of the breaker.

d) Opening on phase opposition.

22.11.0. ACCESSORIES

22.11.1. **Gas Pressure Detector**

The circuit breaker shall be provided with gas pressure monitor with temperature compensation for initiating alarm and locking the operating mechanism in the event of abnormality. **Gas pressure monitor shall be combined for all three phases for (145kV and 66kV) Circuit Breakers. Each phase of Circuit Breaker shall be provided with pressure gauge with Red and Green zone and pressure level marked on the dial.**

22.11.2. **Position Indicator**

Each pole of the circuit breaker shall be provided with a position indicator.

22.11.3. **Terminals**

Each circuit breaker shall be provided with suitable terminal pads of high conductivity aluminium alloy for connecting to the line.

22.11.4. **Auxiliary Switches**

Each circuit breaker shall be equipped with auxiliary switches with sufficient number of contacts for control, indication and interlocking purposes. Twelve normally open and twelve normally closed contacts shall be provided as spares. All contacts shall be rated for the DC voltage specified in data sheet.

22.11.5. **Terminal Blocks**

All accessories, spare contacts of contactors and control devices shall be completely wired up to terminal block. All wirings which are connected to external circuit shall be terminated on terminal blocks installed in the control cabinet. The terminal blocks provided shall have twenty (20) percent spares. **Each terminal block shall be suitable to receive two conductors of minimum 2.5sqmm copper.**

22.11.6. Operating mechanism housing shall be supplied with all required accessories including the following:

a) Padlocks and duplicate keys.

b) Space heaters equipped with automatic thermostatic control.

c) Local/remote changeover switch.

d) Manually operated tripping push button/lever (mechanical) conveniently located to trip all three phases simultaneously.

e) Control switches to cut off control power supplies.

f) Fuses as required.

g) Two earthing terminals.

h) Auxiliary relays required for satisfactory operation.

i) Motor contactor with thermal release

j) Provision for mechanical interlock with isolator.

k) Indication Lamps for On/OFF operation

22.11.06:

22.12.0. SUPPORT STRUCTURES

22.12.1. The Circuit Breakers shall be suitable for mounting on steel structures.

22.12.2. The support structure shall be of steel hot dip galvanised type. The height of support structure shall be designed to keep the bottom most live part and bottom of insulators of circuit breakers at minimum clearance from the plinth as specified in data sheet.

22.12.3. All necessary galvanised bolts, nuts and washers to complete the erection shall be furnished including the embedded anchor bolts for securing the supporting structure to the concrete foundations.

22.12.4. **The support structures shall be capable to withstand the minimum seismic acceleration of 0.36 g in horizontal direction and 0.6g in vertical direction.**

22.13.0. NAME PLATES

22.13.1. All equipment shall have non-corrosive name plates fix at a suitable position indelibly mark with full particular there on in accordance with the standard adapted.

22.14.0. EARTHING

22.14.1. Two earthing pads shall be provided on each supporting structure. Each operating mechanism control cabinet or terminal box mounted on the supporting structure shall also be connected to an earthing pad. Separately mounted control cabinets shall be provided with two earthing pads adjacent to the base of the cabinet. The earthing connection shall be bolted type and suitable for receiving **75mm x 12mm GS strip.**

22.15.0. TERMINAL CONNECTORS

22.15.1. The equipment shall be supplied with required number of terminal connectors of approved type suitable for ACSR conductors. The type of terminal connector, size of connector, material, and type of installation shall be approved by the Employer, as per installation requirement while approving the equipment drawings.

22.16.0. TESTS

22.16.1. All routine tests shall be carried out in accordance with relevant IS. All routine/acceptance tests shall be witnessed by the AEGCLs authorised representative. The tests shall include the following:

a) Routine/Acceptance Tests (all units) i)Mechanical Operation tests

ii)Power frequency voltage withstand test (dry) iii)Tests on auxiliary & control circuits

iv) Measurement of resistance of the main circuit.

v) Insulation Resistance Test

b)Type Tests:

The bidder shall furnish type test certificates and results for the following tests along with the bid for breaker of identical design.

i) Breaking(terminal fault, L90,etc) and making capacity test

ii) Short-time current withstand test

iii) Temperature rise tests

iv) Lightning Impulse voltage test

v) Operating Duty test

vi) Pole Discrepancy test

vii) Power Frequency withstand test

viii) IP degree of protection of operating mechanism enclosure

ix) RIV/PD test

x) Contact Resistance of CB

xi) IR value test for operating mechanism circuits

xii) Creepage distance test

c) **Test Certificates**

Copies of routine/acceptance test certificates shall be produced with the endorsement of the inspecting authority to the Employer before effecting despatch. The test report shall contain the following information.

i) Complete identification data, including serial No. of the breaker.

ii) Method of application, where applied, duration and interpretation of results in each test.

22.17.0. PRE-COMMISSIONING TESTS

22.17.1. Contractor shall carry out following tests as pre-commissioning tests. Contractor shall also perform any additional test based on specialties of the items as per approved document of the equipment AEGCL without any extra cost to the AEGCL. The Contractor shall arrange all instruments required for conducting these tests along with calibration certificates and shall furnish the list of instruments to AEGCL for approval.

(a) Insulation resistance of each pole.

(b) Check adjustments, if any suggested by manufacturer.

(c) Breaker closing and opening time.

(d) Slow and Power closing operation and opening.

(e) Trip free and anti-pumping operation.

(f) Minimum pick-up voltage of coils.

(g) Contact resistance measurement.

(h) Functional checking of control circuits interlocks, tripping through protective relays and auto reclose operation.

(i) Insulation resistance of control circuits, motor etc.

(j) Resistance of closing and tripping coils.

(k) SF6 gas leakage check.

(l) Dew Point Measurement

(m) Verification of pressure switches and gas density monitor.

(n) Checking of mechanical ‘CLOSE’ interlock, wherever applicable.

(o) Testing of grading capacitor.

(p) Resistance measurement of main circuit.

(q) Checking of operating mechanisms

(r) Check for annunciations in control room.

(s) **Sniffer test of VCB**

22.18.0. SPECIAL TOOLS AND TACKLES

22.18.1. The Bidder shall furnish a list of any special tools and tackles required for maintenance and operation purposes with recommended quantities for each substation.

22.19.0. TECHNICAL DATA SHEET FOR CIRCUIT BREAKER

Sl. No.	**Particulars**	**Unit**	**Data for 132kV CB**	**Data for 66kV CB**	**Data for 33 kV CB**
I	**II**	**III**	**IV**	**V**	**VI**
1	Type		SF_6	SF_6	VCB
2	No of poles		3 (3 Phase Ganged Unit)	3 (3 Phase Ganged Unit)	3 (3 Phase Ganged Unit)
3	Service		Outdoor	Outdoor	Outdoor
4	Rated System Voltage	kV	132	66	33
5	Highest System Voltage	kV	145	72.5	36
6	System earthing		Solidly earthed system	Solidly earthed system	Solidly earthed system
7	Rated Voltage of Breaker	kV	145	72.5	36
8	Rated Continuous Current	Amps	3150	2000	**2500/2000/1600/1250**
9	Rated Frequency	Hz	50	50	50
10	Rated Short Circuit breaking current (I) - 3secs - symmetrical	kA RMS	40	**31.5**	31.5
11	Rated Short Circuit making current	kA PEAK	2.5*I	2.5*I	2.5*I
12	Duty cycle		0-0.3 Sec - CO - 3 Min -CO	0-0.3 Sec - CO -3 Min - CO	0-0.3 Sec - CO -3 Min -CO
13	First pole to clear factor		1.3	1.3	1.3
14	Operating time				
	i) Opening Time	ms	Not exceeding 50 ms	Not exceeding 50ms	Not exceeding 50 ms
	ii) Closing Time D	ms	**Not exceeding** 100 ms	**Not exceeding** **100 ms**	Not exceeding **100 ms**

Sl. No.	Particulars	Unit	Data for 132kV CB	Data for 66kV CB	Data for 33 kV CB
I	II	III	IV	V	VI
15	Insulation level				
	i) One minute Power Frequency withstand Voltage (Dry)	kV RMS	275	140	75
	ii) Full Wave Impulse withstand Voltage (1.2/50 µsec)	kV Peak	650	325	170
16	Minimum clearance between phases	mm	1300	630	320
17	Minimum clearance between phase to earth	mm	1300	630	320
18	Minimum Ground clearance (from bottom most live part to plinth level)	mm	4600	3700	3700
19	Minimum clearance from bottom of support insulator to plinth level	mm	2500	2500	2500
20	i) Minimum Creepage Distance (Total)	mm	4495	2247.5	1116
	ii) Minimum Creepage Distance (Protected)	mm	2250		460
21	Operating mechanism a) Type		Spring Charged	Spring Charged	Spring Charged
	b) Rated 3 Phase, 50Hz Voltage for Drive Motor	V	220AC	220AC	220AC
	c) Rated voltage of Shunt trip coil & operating range	V. DC	220 or110[50% - 110%]	220 or110[50% - 110%]	220 or 110 [50% - 110%]
	d) Rated voltage of Closing coil & operating range	V. DC	220 or 132 [80% - 110%]	220 or 132 [80% - 110%]	220 or 132 [80% - 110%]
	e) No. of trip coils	No	2 per CB	2 per CB	2 per CB
	f) No. of closing coils	No	1 per CB	1 per CB	1 per CB

Sl. No.	**Particulars**	**Unit**	**Data for 132kV CB**	**Data for 66kV CB**	**Data for 33 kV CB**
I	**II**	**III**	**IV**	**V**	**VI**
	g) No of spare auxiliary contacts & contact rating	Nos AMPS	12 N/O+12 N/C (per CB) 10 A at 240V AC & 4A at 220V/ 110V DC	12 N/O+12 N/C (per CB) 10 A at 240V AC & 4A at 220V/ 110V DC	12 N/O+12 N/C (per CB) 10 A at 240V AC & 2A at 220V/ 110V DC
	h) Minimum thickness of steel sheet for control cabinet	mm	3	3	3
	i) Enclosure Protection		IP55	IP55	IP55
22	Reclosing		Three Phase auto reclosing	Three Phase auto reclosing	Three Phase auto reclosing
23	Support structure (Painted / Galvanised)		Galvanised	Galvanised	Galvanised
24	All other parts (Painted / Galvanised)		Synthetic enamel shade 631 of IS5 (125 microns)	Synthetic enamel shade 631 of IS5 (125 microns)	Synthetic enamel shade 631 of IS5 (125 microns)
25	Minimum size of control wiring (Copper)	Sq. mm	2.5	2.5	2.5
26	ITRV and TRV of CB interrupter		IEC	IEC	IEC

CHAPTER 23: TECHNICAL SPECIFICATION FOR 132KV & 33KV CURRENT TRANSFORMERS (AIS)

23.1.0 SCOPE OF CONTRACT

This Section of the Specification covers general requirements for design, engineering, manufacture, assembly and testing at manufacturer's worksof 132kV, 66kV and 33 kV outdoor Current Transformers.

23.2.0 STANDARDS

23.2.1 The equipment covered by this specification shall, unless otherwise stated be designed, constructed and tested in accordance with the latest revisions of relevant Indian Standards and shall conform to the regulations of local statutory authorities.

23.2.2 In case of any conflict between the Standards and this specification, this specification shall govern.

23.2.3 The current transformer shall comply also with the latest issue of the following Indian standard.

(i)	IS: 2705(Part-I)	Current transformers: General requirement.
(ii)	IS: 2705(Part-II)	Current transformers : Measuring Current transformers
(iii)	IS: 2705(Part-III)	Current transformers : Protective Current transformers
(iv)	IS: 2705(Part-IV)	Current transformers: Protective Current transformers for special purpose application.
(V)	**All relevant IEC**	

23.3.0 GENERAL IpREQUIREMENTS

23.3.1 The cores of the instrument transformers shall be of high grade, non-aging CRC steel of low hysteresis loss and high permeability.

23.3.2 Current transformers shall be of Live Tank design.

23.3.3 The instrument transformers shall be truly hermetically sealed to completely prevent the oil inside the tank coming into contact with the outside temperature. To take care of oil volume variation the tenderer are requested to quote the current transformers with stainless steel diaphragm (bellow).

23.3.4 The instrument transformers shall be completely filled with oil.

23.3.5 A complete leak proof shrouded secondary terminal arrangement shall be provided with instrument transformers, secondary terminals shall be brought into weather, dust and vermin proof terminal box. Secondary terminal boxes shall be provided with facilities for easy earthing, shorting, insulating and testing of secondary circuits. The terminal boxes shall be suitable for connection of control cable gland. IP rating of terminal box shall be IP 55. Spare terminals shall be provided. **CT secondary shorting links shall be provided along with one terminal earthing arrangement of CT winding. All doors and removable covers and plates shall be sealed all around with neoprene gaskets or similar arrangement**.

23.3.6 All instrument transformers shall be of single phase unit.

23.3.7 The instrument transformers shall be so designed to withstand the effects of temperature, wind load, short circuit conditions and other adverse conditions.

23.3.8 All similar parts, particularly removable ones, shall be interchangeable with one another.

23.3.9 All cable ferrules, lugs, tags, etc. required for identification and cabling shall be supplied complete for speedy erection and commissioning as per approved schematics.

23.3.10 The instrument transformers housing shall be porcelain.

23.3.11 All steel work shall be degreased, pickled and phosphated and then applied with two coats of Zinc Chromate primer and two coats of finishing synthetic enamel paint.

23.3.12 Test terminal for tan-delta/capacitance shall be provided for 132kV CT's.

23.3.13 Accuracy specified shall be maintained at 25% of rated burden.

23.3.14 All winding(Primary/Secondary) shall be of copper. Aluminium is not acceptable

23.4.0 INSULATING OIL

The quantity of insulating oil for instrument transformers and complete specification of oil shall be stated in the tender. The insulating oil shall conform to the requirement of latest edition of IS: 335

23.5.0 COMMON MARSHALLING BOXES (shall be supplied by CT manufacturer)

23.5.1 The outdoor type common marshalling boxes shall conform to the latest edition of IS 5039 and other general requirements specified hereunder.

23.5.2 The common marshalling boxes shall be suitable for mounting on the steel mounting structures of the instrument transformers.

23.5.3 One common marshalling box shall be supplied with each set of instrument transformers. The marshalling box shall be made of sheet steel and weather-proof. The thickness of sheet steel used shall be not less than 3.0 mm. It is intended to bring all the secondary terminals to the common marshalling. The marshalling box shall be of hot dipped galvanized steel.

23.5.4 The enclosures of the common marshalling boxes shall provide a degree of protection of not less than IP 55 (As per IS 2147).

23.5.5 The common marshalling boxes shall be provided with double hinged front doors with pad locking arrangement. All doors and removable covers and plates shall be sealed all around with neoprene gaskets or similar arrangement.

23.5.6 Each marshalling box shall be fitted with terminal blocks made out of moulded non-inflammable plastic materials and having adequate number of terminals with binding screws washers etc. Secondary terminals of the instrument transformers shall be connected to the respective common marshalling boxes. All out going terminals of each instrument transformer shall terminate on the terminal blocks of the common marshalling boxes. The terminal blocks shall be arranged to provide maximum accessibility to all conductor terminals.

23.5.7 Each terminal shall be suitably marked with identification numbers. Not more than two wires shall be connected to any one terminal. At least 20 % spare terminals shall be provided over and above the required number. All terminals of control circuits shall be wired up to marshalling box including spare terminals evenly distributed on all TB's.

23.5.8 All terminal strips shall be of isolating type terminals and they will be of minimum 10 A continuous current rating.

23.5.9 All cable entries shall be from bottom. Suitable removable gland plate shall be provided on the box for this purpose. Necessary number of cable glands shall be supplied fitted on to this gland plate. Cable glands shall be screw on type and made of brass.

23.5.10 Each common marshalling box shall be provided with two numbers of earthing terminals of galvanised bolt and nut type.

23.5.11 All steel, inside and outside work shall be degreased, pickled and phosphated and then applied with two coats of Zinc Chromate primer and two coats of finishing synthetic enamel paint. The colour of finishing paint shall be as follows: -

i) Inside: Glossy White

ii) Outside: Light Grey (Shade No. 697 of IS: 5)

23.6.0 BUSHINGS AND INSULATORS

23.6.1 Bushings and Insulators shall be of Porcelain, Solid core type. Porcelain used for the manufacture of bushings and insulators shall be homogeneous, free from defects, cavities and other flaws or imperfections that might affect the mechanical or dielectric quality and shall be thoroughly vitrified, tough and impervious to moisture **and shall conform to IEC 60135, 60168/IS.**

23.6.2 Glazing of the porcelain shall be of uniform brown colour, free from blisters, burns and other similar defects. Bushings shall be designed to have sufficient mechanical strength and rigidity for the conditions under which they will be used. All bushings of identical ratings shall be interchangeable.

23.6.3 Puncture strength of bushings shall be greater than the dry flashover value. When operating at normal voltage, there shall be no electric discharge between the conductors and bushing. No radio interference shall be caused by the bushings when operating at the normal rated voltage

23.6.4 The design of bushing shall be such that the complete bushing is a self-contained unit and no audible discharge shall be detected at a voltage up to a working voltage (Phase Voltage) plus 10%. The minimum creepage distance for severely polluted atmosphere shall be 31 mm/KV.

23.6.5 Sharp contours in conducting parts should be avoided for breakdown of insulation. The insulators shall be capable to withstand the minimum seismic acceleration of 0.5 g in horizontal direction and 0.6g in vertical direction..

23.6.6 Bushings shall satisfactorily withstand the insulation level specified in data sheet.

23.6.7 Rain shed/drain cover/dome shall be present in CT.

23.6.8 Bellow level indicator shall be present in CT.

23.6.9 Nitrite butyl rubber/Neoprene gaskets shall be used.

23.6.10 Critical flashover voltage of insulator and bushing shall be provided.

23.7.0 TESTS

23.7.1 **Routine/Acceptance Tests (all units)**

All routine tests shall be carried out in accordance with relevant Standards. All routine/acceptance tests shall be witnessed by the Employer/his authorised representative.

23.7.2 **Type Tests:** The bidder shall furnish type test certificates and results for the all tests as per relevant Standards along with the bid for current and potential transformers of identical design. Type test certificates so furnished shall not be older than 5 (five) years as on date of Bid opening.

23.7.3 **QAP:** QAP indicating all brought out materials tests shall be submitted.

23.8.0 NAME PLATES

All equipment shall have non-corrosive name plates fix at a suitable position indelibly mark with full particular there on in accordance with the standard adapted. Thickness (1mm), purchase order, project name, serial no etc. shall be present in the Name plate.

23.9.0 MOUNTING STRUCTURES

23.9.1 All the equipment covered under this specification shall be suitable for mounting on steel structures. Supply of mounting on **galvanised** structures is also in the scope of this tender.

23.9.2 Each equipment shall be furnished complete with base plates, clamps, and washers etc. and other hardware ready for mounting on steel structures.

23.10.0 SAFETY EARTHING

23.10.1 The non-current carrying metallic parts and equipment shall be connected to station earthing grid with two terminals.

TERMINAL CONNECTORS (Shall be under manufacturer scope)

23.11.1 The equipment shall be supplied with required number of terminal connectors of approved type suitable for ACSR. The type of terminal connector, size of connector, material, and type of installation shall be approved by the AEGCL, as per installation requirement while approving the equipment drawings. No part of a clamp shall be less than 12mm. thick. All connectors shall be of Aluminium Alloy and type tested as per IEC/IS including RIV and short circuit.

PRE-COMMISSIONING TESTS

23.12.1 Contractor shall carry out following tests as pre-commissioning tests. Contractor shall also perform any additional test based on specialties of the items as per the field 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.

(a) **Current Transformers**

(i) Insulation Resistance Test for primary and secondary.

(ii) Polarity test.

(iii) Ratio identification test - checking of all ratios on all cores by primary injection of current.

(iv) Dielectric test of oil (wherever applicable).

(v) Magnetising characteristics test.

(vi) Tan delta and capacitance measurement

(vii) Secondary winding resistance measurement

(viii) Contact resistance measurement (wherever possible/accessible).

(ix) Knee-point voltage measurement

23.13.0 TECHNICAL DATA SHEET FOR CURRENT

23.13.1 For **145/72.5/**36 kV CTs the instrument security factor at all ratios shall be less than five (5) for metering core. If any auxiliary CTs/reactor are used in the current transformers then all parameters specified shall have to be met treating auxiliary CTs as an integral part of the current transformer. The auxiliary CTs/reactor shall preferably be inbuilt construction of the CTs. In case these are to be mounted separately these shall be mounted in the central marshalling box suitably wired upto the terminal blocks.

23.14.0 TYPE AND RATING:

23.14.1All instrument transformer shall be outdoor type, single phase, oil immersed, self-cooled suitable for mounting on steel structure. The instrument transformer shall have the following ratings and particulars.

SL	A. Item		Ratings and Particulars

No.				
I	**II**	**III**	**IV**	
A	Nominal system voltage	132 kV	33 kV	66 kV
B	Highest system voltage, kV	145	36	72.5
C	Rated frequency, HZ	50	50	50
D	System earthing	Solidly earthed	Solidly earthed	Solidly earthed
E	Insulation level			
a)	Full Wave Impulse withstand voltage: kVp (1.2/50)	650	170	325
b)	One-minute p.f. Withstand voltage, kV (r.m.s.) (dry and wet)	275	70	140
F	Short time current for 3 seconds, kA	40	31.5	31.5
G	Minimum creepage distance, mm	4495	1116	2247.5
H	Temperature rise	As per IS	As per IS	As per IS
I	**C.T.**			
	(i) No. of Cores	5	2/5	5
	(ii) Transformation ratio	As per BoQ		
	(iii) Rated out put			
	(a) Core-1	20 VA	20 VA	20 VA
	(b) Core-2	20 VA	20 VA	20 VA
	(c) Core-3	(PX CLASS)	PX (for trafo only)	PX
	(d) Core-4	(PX CLASS)	PX (for trafo only)	PX
	(e) Core-5	(PX CLASS)	PX (for trafo only)	PX
	(iv) Accuracy class			
	(a) Core-1	0.2S	0.2S	0.2S
	(b) Core-2	5P20/PX (trafo)	5P20/PX (trafo)	5P20
	(c) Core-3	PX	PX (for trafo only)	PX
	(d) Core-4	PX	PX (for trafo only)	PX
	(e) Core-5	PX	PX (for trafo only)	PX
	(vi) Instrument security factor			

	(a) Core-1	<5	<5	<5
	(b) Core-2	-	-	-
	(c) Core-3	-	-	-
	(d) Core-4	-	-	-
	(e) Core-5	-	-	-
	(vii) Minimum Knee point voltage, Volts			
	(a) Core-1	-	-	-
	(b) Core-2	-	-	-
	(c) Core-3	1:1 of CT ratio min	1:1 of CT ratio min	1:1 of CT ratio min
	(d) Core-4	1:1 of CT ratio min	1:1 of CT ratio min	1:1 of CT ratio min
	(e) Core-5	1:1 of CT ratio min	1:1 of CT ratio min	1:1 of CT ratio min
	(viii) Maximum secondary resistance, ohm			
	(a) Core-1	-	-	-
	(b) Core-2	-	-	-
	(c) Core-3	<3	<3	<3
	(d) Core-4	<3	<3	<3
	(e) Core-5	<3	<3	<3
	(ix) Maximum exciting current, at Vk/4 mA			
	(a) Core-1	-	-	-
	(b) Core-2	-	-	-
	(c) Core-3	-	-	-
	(d) Core-4	-	-	-
	(e) Core-5	-	-	-
	Tandelta at Um/ root 3	< 3	< 3	< 3
	Rated extended primary current	120%	120%	120%

Note:

(i) It is intended to use different ratios of the same CT at the same time for various protections and metering cores. The CTS should therefore be suitable for the above purpose by secondary tapings only. The ratio change by secondary taps is acceptable as long as the required CT specifications are achieved at all ratios.

(ii) The knee point voltage specified above shall be at higher ratio/ taps.

(iii) CT and PT sizing calculations shall be submitted. Burden values and knee point voltage, shall be decided as per the calculations during detailed engineering

(iv) For Station service bay equipments rated system voltage shall be 33kV and highest system voltage shall be 72.5kV.

CHAPTER 24: TECHNICAL SPECIFICATION FOR DG SET

- **Applicable Standards**

The Diesel Standby Generator and its components shall conform to the latest applicable standards specified below:

Diesel Engines for General Purposes	:	BS 5514 / ISO 3046
The Electrical Performance of Rotating Electrical Machinery	:	BS 5000
Rotating Electrical Machines	:	IS 4722
Circuit breakers	:	IS-13118, BS-5311, IEC-56 & 694, BSEN-60942 (P-2)
Air break switches air break disconnectors, air break switch disconnectors and fuse combination units for voltage not exceeding1000 V AC or 1200 V DC	:	IS-13947 (P-3), BS-EN60947, IEC-60947-3
Current transformer	:	IS-2705/BS-7626, IEC-60185
Voltage transformer	:	IS-3156/BS-7625/IEC 60186
Electrical Relays	:	IS-3231, 3842/BS-142/IEC-60255
Contactors for voltage not exceeding 1000 V ac or 1200 VDC	:	IS-13947 Part-IV/ BSEN-60947-4-1/ IEC-60947-4-1
Control Switches	:	IS-6875/BSEN-60947 / IEC-60947-4-1
High Voltage Fuse	:	IS-9385/BS-2692/ IEC-60282
Low Voltage Fuse	:	IS-13703/BS-1362 IEC-269-1
Electrical direct acting indicating Instruments	:	IS-1248/BS-89/IEC-60051
A.C. electricity meters of induction type voltage greater than1000 volts	:	IS722, 8530/BS-5685 / IEC-60145, 60211
Resistance wire, tapes and stripes for heating elements	:	IS-3725
Wrought aluminum and aluminum alloy bars, rods, tubes and sections for electrical purposes	:	IS-5082
Specification for copper rods and bars for electrical purposes	:	IS-613
Toggle switches	:	IS-3452/BS-3676
Control switches/push buttons	:	IS-6875/BSEN 60947

Noise and Emission Limit	:	As per latest notification of ministry of Environment and Forests

- **SECTION: DIESEL GENERATOR SET**

24.1. SCOPE OF SUPPLY

24.1.1. The scope covers supply of reputed make Diesel Generator set of stationary type having net electrical output of **100/150/200/250kVA** capacity at specified site conditions of 50o C ambient temperature and 100% relative humidity on FOR site basis. DG set shall be equipped with :(i) Diesel engine complete with all accessories.(ii) An alternator directly coupled to the engine through coupling, complete with all accessories.(iii) Automatic voltage regulator. (iv) Complete starting arrangement, including two nos. batteries (one standby to other) & chargers.(v)Base fr required for fuel transfer system from storage area to fuel tank including electrically driven fuel pump.(xi) All lubricants, consumable, touch up paints etc. for first filing, testing &commissioning at site. The fuel oil for first commissioning will also be provided by the contractor. (xii) AMF panel for control, metering and alarm. (xiii) Enclosure for silent type D.G.Set.

24.2. SCOPE OF SERVICE

24.2.1. The Contractor shall provide following services:

a) Design, manufacture, shop testing including assembly test.
b) Despatch, transportation to site.
c) Erection, testing & commissioning with all equipments/materials required for the purpose.
d) Drawings, data, design calculations and printed erection, operation & maintenance manual.
e) Certification and compliance for meeting noise level & emission parameters and other requirements in accordance with latest Notification of MOEF.

24.3. TECHNICAL REQUIREMENTS

24.3.1. The rating of DG sets are as follows:

- DG set net out put after considering deration for engine and alternator separately due to temperature rise in side the enclosure and on account of power reduction due to auxiliaries shall be 250 kVA, 1500RPM, 0.8Pf, 415V, 3 phases, 50Hz. The above ratings are the minimum requirements.
- DG set net out put after considering deration for engine and alternator separately due to temperature rise inside the enclosure and on account of power reduction due to auxiliaries shall be **100/150/200/250kVA**, 1500RPM, 0.8Pf, 415V,3 phases,50Hz.The above ratings are the minimum requirements.

- DG sets shall also be rated for 110% of full load for 1 hour in every twelve hrs of continuous running.

24.3.2. The output voltage, frequency and limits of variation from open circuit to full load shall be as follows

a) Voltage variation $\pm$5% of the set value provision shall exist to adjust the set value between 90% to 110% of nominal Generator voltage of 415V.
b) Frequency 50Hz $\pm$2%

24.3.3. The Diesel Generator and other auxiliary motor shall be of H class with temperature rise limited to Class-F for temperature rise consideration.

24.3.4. **NOISE LEVEL & EMISSION PARAMETERS**: These shall be as per latest

Notification of MOEF

24.4. PLANT DESIGN

24.4.1. DIESEL ENGINE

24.4.1.1. The engine shall comply with the IS 10002/BS 5514/ISO 3046; latest edition

24.4.1.2. Diesel engine shall be turbo charged multicylinder V-type in line type with mechanical fuel injection system.

24.4.1.3. The engine with all accessories shall be enclosed in a enclosure to make it work Silently (within permissible noise level) without any degradation in its performance.

24.4.1.4. The Diesel Engines shall be directly water cooled. Cooling of water through radiator and fan as envisaged.

24.4.1.5. The fuel used shall be High Speed Diesel oil (HSD) or Light Diesel Oil (LDO) as per IS:1460.

24.4.2. **Air Suction & Filtration**

24.4.2.1.1. Suction of air shall be from indoor for ventilation and exhaust flue gasses will be let out to outside atmosphere, Condensate traps shall be provided on the exhaust pipe.

24.4.2.1.2. Filter shall be dry type air filter with replaceable elements.

24.4.3. FUEL AND LUBRICATING OIL SYSTEM

24.4.3.1.1. The engine shall have closed loop lubricating system. No moving parts shall require lubrication by hand prior to the start of engine or while it is in operation.

24.4.4. ENGINE STARTING SYSTEM

24.4.4.1. Automatic electric starting by DC starter motor shall be provided.

24.4.5. FUEL INJECTION AND REGULATOR

24.4.5.1. The engine shall be fitted with electronic governor suitable for class A-1 as per IS 10000.

24.4.5.2. The engine shall be fitted with a heavy, dynamically balanced fly wheel suitable for constant speed governor duty.

24.4.6. ALTERNATOR

24.4.6.1. The alternator shall comply with BS 2613/IS 4722/IEC 34; latest edition.

24.4.6.2. The alternator shall be of continuously rated duty, suitable for 415 V, 3 phase, 50 Hz. Power development having brush-less, synchronous, self-excited, self-regulating system.

24.4.6.3. The alternator shall be drip-proof, screen protected as per IP-23 degree of Protection.

24.4.6.4. The rotor shall be dynamically balanced to minimize vibration.

24.4.6.5. The alternator shall be fitted with shaft mounted centrifugal fan and neutral earthing provision.

24.4.6.6. It shall have the winding of class H but limited to Class-F for temperature rise consideration.

24.4.6.7. The Alternator regulator shall be directly coupled to the engine and shall be complete with the excitation system, automatic voltage regulation of +/- 1%, voltage adjusting potentiometer and under/over speed protection.

24.4.7. Terminal Box

24.4.7.1 Six (6) output terminals shall be provided in alternator terminal box. Terminals shall be Suitable for 2 No. of single core, 3½Core 300 mm^2 XLPE cable for 250 kVA DG set. The neutral shall be formed in AMF panel. The generator terminal box shall be suitable to house necessary cables and should be made of non-magnetic material.

24.4.7.2 The alternator with all accessories shall be enclosed in a enclosure to make it work Silently (within permissible noise level)

24.4.8. **COUPLING**

24.4.8.1. The engine and alternator shall be directly coupled by means of self- aligning flexible flange coupling to avoid misalignment.

24.4.8.2. The coupling shall be provided with a protecting guard to avoid accidental contract.

24.4.9. **MOUNTING ARRANGEMENT**

24.4.9.1. The engine and alternator shall be mounted on a common heavy duty, rigid fabricated steel base frame constructed from ISMC of suitable sections.

24.4.9.2. Adequate number of anti-vibrations mounting pads shall be fixed on the common base frame on which the engine and the alternator shall be mounted to isolate the vibration from passing on to the common base frame or the foundation of the D.G. Set.

24.4.10. **PERIPHERALS**

24.4.10.1. **FUEL TANK**

a) The Fuel tank of suitable capacity shall be provided on a suitably fabricated steel platform. The tank shall be complete with level indicator marked in litres, filling inlet with removable screen, an outlet, a drain plug, an air vent, an air breather and necessary piping. The tank shall be painted with oil resistant paint and shall be erected in accordance with Indian explosive act of 1932. Fuel tank shall be installed at the base with the level indicator, drain plug, air vent inlet and outlet connection, manhole etc. as per requirement.

b) For transferring fuel to Fuel tank transfer pump is envisaged. The capacity of transfer pump shall be adequate to fill the day tank in about 30 minutes. Fuel pump shall be electrically driven.

24.4.10.2. **BATTERY and BATTERY CHARGER**

a) Two nos. 24V batteries complete with all leads, terminals and stand shall be provided. Each battery shall have sufficient capacity to give 10 nos. successive starting impulse to the diesel engine.

b) The battery charger shall be complete with transformer, suitable rating (415 V, Ph., 50 Hz./**240V**,1Ph.,50Hz)rectifier circuit, charger at selector switch for “trickle”/’boost’charge,

c) D.C. ammeter & voltmeter, annunciation panel for battery charge indication / loading / failures.

d) The charger shall float and Boost Charge the battery as per recommendation of manufacturer of battery. The charger shall be able to charge a fully discharged battery to a state of full charge in 8 Hrs. with 25% spare capacity.

e) Manual control for coarse and fine voltage variation shall be provided. Float charger shall have built-in load limiting features.

f) Ripple shall not be more than 1%(r.m.s) to get smooth DC voltage shall be provided.

g) Charger shall be provided with Out-put Voltmeter & Ammeter.

h) Changeover scheme for selecting battery and battery charger by changeover switch should be provided.

24.5. CONTROL AND INSTRUMENTATION

24.5.1. Each D.G. Set shall be provided with suitable instruments, relay and protection arrangement, annunciation and indications etc. for proper start up, control, monitoring and safe operation of the unit. One local AMF control panel along with each D.G. set shall be provided by the Supplier to accommodate these instruments, protective relays, all required interlocks, indication lamps, ACB/MCCB with short circuit , overload and earth fault releases, etc. The AMF Panel shall have IP-52 degree of Protection as per IS:12063.

24.5.2. The D.G. sets shall be provided with automatic start facility to make it possible to take full load within 30 seconds of Power Supply failure.

24.5.3. Testing facility for automatic operation of D.G. Set shall be provided in AMF panel.

24.5.4. A three-attempt starting facility using two impulse timers and summation timer for engine shall be proved and if the voltage fails to develop within 40 sec. from receiving the first impulse, the set shall block and alarm to this effect shall be provided in the AMF panel.

24.5.5. Following instruments shall be provided with Diesel Engine

a) Lub oil pressure gauge

b) Water temperature thermometers

c) Engine tachometer/HR

d) Any other instruments necessary for DG Set operation shall be provided.

24.5.6. DG set shall be capable of being started/ stopped manually from remote as well as local. (Remote START/STOP push button shall be provided in 415V ACDB). However, interlock shall be provided to prevent shutting down operation as long as D.G. Circuit breaker is closed. The **DG set shall be capable to start the highest rated motor with all other loads running.**

24.5.7. The diesel generator shall commence a shutdown sequence whenever any of the following conditions appear in the system:

a) Overspeed

b) Overload

c) High temperature of engine and cooling water.

d) High temperature inside enclosure

e) Low lube oil pressure

f) Generator differential protection

g) Short circuit protection

h) Under voltage

i) Over voltage

j) Further interlocking of breaker shall be provided to prevent parallel operation of DG set with normal station supply.

24.5.8. Following indication lamps for purposes mentioned as under shall be provided in AMF panel:

24.5.8.1. Pilot indicating lamp for the following:

a) Mains ON
b) Alternator ON
c) Charger ON/OFF
d) Breaker ON/OFF
e) Main LT Supply ON/OFF

24.5.8.2. Visual annunciation shall be provided for set shut down due to :

a) engine overheating
b) low oil pressure
c) lack of fuel
d) Set failed to start in 30 secs after receiving the first start impulse
e) high cooling water temperature
f) Low level in daily service fuel tank
g) Overspeed trip
h) Audio & visual Annunciation for alternator fault.
i) High temperature of cooling water

24.5.8.3. Thermostatically controlled space heaters and cubicle illumination operated by Door Switch shall be provided in AMF panel. Necessary isolating switches and fuses shall also be provided.

24.5.8.4. AMF panel shall have facility for adjustment of speed and voltage including fine adjustments in remote as well as in local mode.

24.5.8.5.
Following shall also be provided in AMF panel:
a. Frequency meter
b. **3** nos. single phase CT for metering
c. **3** nos. single phase CT's with 300V & RCT 0.25 ohms for differential protection of DG set on neutral only for 250KVA**(by LT switchgear manufacturer).**
d. One (1) DC ammeter (0-40A)
e. One (1) DC volt meter (0-30V)
f. One (1) voltmeter selector switch
g. One (1) AC Ammeter **with suitable scale range (96mmX 96mm)**
h. One (1) AC Voltmeter **with suitable scale range (96mmX 96mm)**
i. Three (3) timer (24VDC)
j. Two (2) Auto/Manual switch
k. Two (2) Auto/Test/Manual selector switch
l. Eleven (11) auxillary contact suitable for 24 VDC.
m. One (1) Motorised potential meter for voltage adjustment
n. Two (2) set battery charger as specified in Technical specification.
o. One (1) set phase & neutral busbar
p. **Reverse power relay and other protection relays as required**
q. Any other item required for completion of the control scheme shall be deemed to be included.

24.6. D.G. SET Enclosure

24.6.1. General requirements

24.6.1.1. Diesel engine, alternator, AMF panel, Batteries and Chargers shall be installed outdoor in a suitable weather-proof enclosure which shall be provided for protection from rain, sun, dust etc. Further, in addition to the weather proofing, acoustic enclosures shall also be provided such that the noise level of acoustic enclosure DG set shall meet the requirement of MOEF. The diesel generator sets should also conform to Environment (Protection) Rules, 1986 as amended. An exhaust fan with louvers shall be installed in the enclosure for temperature control inside the enclosure. The enclosure shall allow sufficient ventilation to the enclosed D.G. Set so that the body temperature is limit to 50°C. The air flow of the exhaust fan shall be from inside to the outside the shelter. The exhaust fan shall be powered from the DG set supply output so that it starts with the starting of the DG set and stops with the stopping of the DG set. The enclosure shall have suitable viewing glass to view the local parameters on the engine.

24.6.1.2. Fresh air intake for the Engine shall be available abundantly; without making the Engine to gasp for air intake. A chicken mess shall be provided for air inlet at suitable location in enclosure which shall be finalised during detailed engineering.

24.6.1.3. The Enclosure shall be designed and the layout of the equipment inside it shall be such that there is easy access to all the serviceable parts.

24.6.1.4. Engine and Alternator used inside the Enclosure shall carry their manufacturer's Warranty for their respective Models and this shall not degrade their performance.

24.6.1.5. Exhaust from the Engine shall be let off through Silencer arrangement to keep the noise level within desired limits. Interconnection between silencer and engine should be through stainless steel flexible hose/ pipe.

24.6.1.6. All the Controls for Operation of the D.G. Set shall be easily assessable. There should be provision for emergency shut down from outside the enclosure.

24.6.1.7. Arrangement shall be made for housing the Battery set in a tray inside the Enclosure.

24.6.2. **Construction Features:**

24.6.2.1. The enclosure shall be fabricated from at least 14 Gauge CRCA sheet steel and of Modular construction for easy assembling and dismantling. The sheet metal components shall be pre-treated by Seven Tank Process and Powder coated (PURO Polyester based) both-in side and out side – for long life. The hard-ware and accessories shall be high tensile grade. Enclosure shall be given a lasting anti-rust treatment and finished with pleasant environment friendly paint. All the hardware and fixtures shall be rust proof and able to withstand the weather conditions.

24.6.2.2. Doors shall be large sized for easy access and provided with long lasting gasket to make the enclosure sound proof. All the door handles shall be lockable type.

24.6.2.3. The Enclosure shall be provided with anti-vibration pads (suitable for the loads and vibration they are required to carry) with minimum vibration transmitted to the surface the set is resting on.

24.6.2.4. High quality rock wool of required density and thickness shall be used with fire retardant thermo – setting resin to make the Enclosure sound proof.

24.6.3. **Provision for Neutral/Body Earthing**

24.6.3.1. Points shall be available at two side of the enclosure with the help of flexible copper wires from alternator neutral, and electrical panel body respectively. The earthing point shall be isolated through insulator mounted on enclosure.

24.7. INSTALLATION ARRANGEMENT

24.7.1. DG set enclosed in enclosure shall be installed on Concrete Pedestal 300mm above FGL

24.8. DOCUMENTS

24.8.1. Following drawings and data sheet shall be submitted for approval:

(i) Data sheet for Engine, Alternator, Battery, AMF panel and Enclosure
(ii) GA drawing of DG set
(iii) Layout of DGset in the enclosure along with sections
(iv) GA and schematic of AMF panel
(v) Arrangement of inclined roof and pedestal.
(vi) DG sizing calculation

24.8.2. The D G Set shall be supplied with

(i) D G Set test certificate

(ii) Engine Operation & maintenance Manual.
(iii) Engine Parts Catalogue.
(iv) Alternator Operation, maintenance & Spare parts Manual.
(v) Alternator test certificate.

24.9. TESTS

a) The Diesel generator sets shall be tested for routine and acceptance tests as per the relevant IS/IEC standards.

b) The type test report for diesel engine and alternator are not required to be submitted for the makes indicated at approved list of subvendors. For the new makes (Other than those indicated at approved list of subvendors) type test reports as per relevant standard shall be submitted for purchaser's approval.

24.10. Commissioning Checks

In addition to the checks and test recommended by the manufacturer, the Contractor shall carryout the following commissioning tests to be carried out at site.

1. Load Test

The engine shall be given test run for a period of atleast 6 hours. The set shall be subjected to the maximum achievable load as decided by Purchaser without exceeding the specified DG Set rating :

During the load test, half hourly records of the following shall be taken :

a) Ambient temperature.
b) Exhaust temperature if exhaust thermometer is fitted.
c) Cooling water temperature at a convenient point adjacent to the water output from the engine jacket.
d) Lubricating oil temperature where oil cooler fitted.
e) Lubricating oil pressure.
f) Colour of exhaust gas
g) Speed
h) Voltage, wattage and current output. i) Oil tank level

The necessary load to carryout the test shall be provided by the purchaser.

2. Insulation Resistance Test for Alternator

Insulation resistance in mega-ohms between the coils and the frame of the alternator when tested with a 500V megger shall not be less than IR=2x(rated voltage in KV)+1.

3. Check of Fuel Consumption

A check of the fuel consumption shall be made during the load run test. This test shall be conducted for the purpose of proper tuning of the engine.

4. Insulation Resistance of Wiring

Insulation resistance of control panel wiring shall be checked by 500V Megger. The IR shall not be less than one mega ohm.

5. Functional Tests

a) Functional tests on control panel.
b) Functional test on starting provision on the engine.
c) Functional tests on all Field devices.
d) Functional tests on AVR and speed governor.

6. Measurement of Vibration

The vibration shall be measured at load as close to maximum achievable load and shall not exceed 250microns.

7. Noise Level check as per relevant standard

8. The tests shall be carried out with the DG set operating at rated speed and at maximum achievable load. Necessary correction for Test environment condition & background noise will be applied as per IS:12065.

CHAPTER 25: TECHNICAL SPECIFICATION FOR IPS ALUMINIUM TUBE

25.1 STANDARDS:

Design, manufacture, performance of the tubular conductor shall comply with all currently applicable standards regulations and safety codes in the locality where the same is to be installed. Unless otherwise, specified, bus bar should conform to the latest applicable Indian standards and in particular to the following:

IS : 5082 : Specification for wrought – Aluminium & Aluminium alloy, bars, rods, tubes and sections for electrical purpose.

Acceptance tests/chemical composition:

IS : 731-1971 : Method of high voltage testing/Corona/RIV.

IS – 2121-1982 : Specification for conductors and earth wire accessories for overhead power lines.

25.1.1 The equipment covered by the specification shall, unless otherwise stated be designed, constructed and tested in accordance with the latest revisions of relevant Indian Standards and shall conform to the regulations of local statutory authorities.

25.1.2 In case of any conflict between the standards and this specification, this specification shall govern.

25.2 SERVICE CONDITIONS:

25.2.1 The plant and materials supplied shall be suitable for operation under the following climatic and other conditions:

a) Peak ambient day temperature in still air :		50ºC
b) Minimum night temperatures :		0ºC
c) Reference ambient day temperature :		50ºC
d) Relative Humidity	a) Maximum :	100 %
	b) Minimum :	10 %
e) Altitude :		Below1000 M above MSL
f) Maximum wind pressure :		As per IS: 802 latest code.
g) Seismic Intensity :		ZONE-V as per IS 1893.

25.3 TECHNICAL OVERVIEW OF ALUMUNIUM TUBULAR CONDUCTOR

General

25.3.1 The Aluminium tubular bus bar shall be extruded from 63401 grade Aluminium alloy with W.P. range 2 treatment. The rigid tubular conductors shall be of aluminium of standard type and designed to operate within set temperature limits and to withstand thermal and electro mechanical forces developed due to short circuits and vibration by wind. Material of Aluminium

Tubular shall be cold drawn aluminium tube with minimum 55% IACS conductivity at 20^o C temperature. (International Annealed Copper standards)
Dimensional tolerances of the aluminium tube shall be as laid down in IS:2673 for the extruded tube.

25.4 SPECIFIC TECHNICAL REQUIREMENT

25.4.1 a) Standard pipe size : 114.3mm (4”)
b) Material : Aluminium of grade 91E Confirming to IS:5082 of 1969
c) Atmosphere : Corrosive and fungicidal
d) Rated voltage :400kV, 220kV,132 kV & 33 kV

25.4.2 The maximum length of tube that can be supplied with and without stationing limitations on transport stipulation shall be indicated in the Bid. Standard length of 7 meters for 4” IPS is preferred.

25.3.1

The Aluminium tubular bus bar shall be extruded from 63401 grade Aluminum alloy with W.P. range 2 treatment. The rigid tubular conductors shall be of aluminium of standard type and designed to operate within set temperature limits and to withstand thermal and electro mechanical forces developed due to short circuits and vibration by wind. Material of Aluminium Tubular shall be cold drawn aluminium tube with minimum 55% IACS conductivity at 20o C temperature. (International Annealed Copper standards) Dimensional tolerances of the aluminium tube shall be as laid down in IS:2673 for the extruded tube.

TECHNICAL SPECIFICATION FOR IPS ALUMINIUM TUBE

Size	Diameter(mm)		Wall thickness	Area	weight	DC Resistance (Max)at 20^{0}C
Inches (“)	Outside	inside	(mm)	(mm$^{2)}$	Kg/m	Micro-ohm/cm
Schedule 40						
1.5	48.26	40.894	3.690	516.13	1.396	60.73
2.5	73.03	62.713	5.160	1099.35	2.980	28.44
3.0	88.90	77.930	5.485	1437.42	3.890	21.75
4.0	114.30	102.26	6.02	2048	5.529	15.30
4.5	117.00	114.30	6.35	2407.00	6.50	
5.0	141.30		9.53	3945.11	10.52	
Schedule 80						
1.5	48.26	38.10	5.08	699.03	1.87	45.44
2.5	73.03	59.0	7.015	1454.19	3.94	21.52
3.0	88.90	73.66	7.62	1945.80	5.27	16.11
4.0	114.30	97.18	8.56	2844.00	7.678	11.00
4.5	120	96	12	4071.50	11.034	

25.4 SPECIFIC TECHNICAL REQUIREMENT

25.4.1 a) Standard pipe size : 114.3mm (4”)
b) Material : Aluminium of grade 91E Confirming to IS:5082 of 1969
c) Atmosphere : Corrosive and fungicidal
d) Rated voltage :400kV, 220kV,132 kV & 33 kV

25.4.2 The maximum length of tube that can be supplied with and without stationing limitations on transport stipulation shall be indicated in the Bid. Standard length of 7 meters for 4” IPS is preferred.

CHAPTER – 26: SPECIFICATION FOR DESIGN AND FABRICATION OF SUBSTATION STEEL STRUCTURES

26.1.0 SCOPE

26.1.1 The scope of this section covers specifications for fabrication, proto-assembly, supply and erection of galvanised steel structures for towers, girders, lightning masts and equipment support structures. Towers, girders and lightning masts shall be lattice type structure fabricated from structural steel conforming to IS 2062 (latest). All equipment support structures shall be fabricated from GI pipe conforming to YST 22 or of higher grade as per IS 806.

26.1.2 Support structure for Circuit breaker and Isolators is not standardized and shall be designed by the Contractor and approved by the Employer. Any other structures of 400kV, 220 kV, 132kV and 33kV class necessary to complete the substation to complete the work in all respects shall be designed by the contractor.

26.1.3 The scope shall include supply and erection of all types of structures including bolts, nuts, washers, hangers, shackles, clamps ant-climbing devices, bird guards, step bolts, inserts in concrete, gusset plates, equipment mounting bolts, structure earthing bolts, foundation bolts, spring washers, fixing plates, ground mounted marshaling boxes (AC/DC Marshaling box & equipment control cabinets), structure mounted marshaling boxes and any other items as required to complete the job.

26.1.4 The connection of all structures to their foundations shall be by base plates and embedded anchor/foundation bolts. All steel structures and anchor/foundation bolts shall be fully galvanized. The weight of the zinc coating shall be at least 0.610 kg/m2 for anchor bolts / foundation bolts and for structural members. One additional nut shall be provided below the base plate which may be used for the purpose of levelling.

26.1.5 In case of equipment support structure, Contractor may require to change the dimensions to match the equipment bus bar height and to match the mounting arrangement of a particular equipment. Further suitable modification shall be carried out in the drawings of equipment support structures by the Contractor in order to suit fixation of accessories such as marshalling boxes, MOM boxes, Control Cabinets, Junction box, surge counter, etc. in the standard structure fabrication drawings. The Contractor will make these changes without any price implication. The final drawings of mounting structures shall be submitted to Employer for approval.

26.2.0 MATERIALS

26.2.1 Structural Steel

The structures shall be of structural steel conforming to any of the grade, as appropriate, of IS 2062 (latest edition) Steel conforming IS 8500 may also be used.

Medium and high strength structural steels with known properties conforming to any other national or international standards may also be used.

26.2.2 Bolts

Bolts used shall conform to IS12427 or bolts of property class 4.6 conforming to IS 6639 may also be used.

High strength bolts, if used (only with steel conforming to IS 8500) shall conform to property class 8.8 of IS 3757. Foundation Bolts shall conform to IS 5624.

Step bolts shall conform to IS 10238

26.2.3 **Galvanisation**

Structural members, plain and heavy washers shall be galvanized in accordance with the provisions of IS 4759.

Spring washers shall be hot dip galvanized as per service grade 4 of IS 4759 or IS 1537.

26.2.4 **Other Materials**

Other materials used in the construction of the supporting structures shall conform to appropriate Indian Standards wherever available.

26.3.0 DESIGN REQUIREMENTS FOR STRUCTURES

26.3.1 This clause and sub-clauses shall be referred only for structures for which design is in the scope of Contractor.

26.3.2 For design of steel structures loads such as dead loads, live loads, wind loads etc. shall be based on IS:875,Parts I to V.

26.3.3 For materials and permissible stresses IS:802, Part-I, Section-2 shall be followed in general. However, additional requirements given in following paragraphs shall be also considered.

26.3.4 Minimum thickness of galvanized tower member shall be as follows:

ITEM	Minimum thickness in mm
Leg members, Ground wire Peak members/ other load carrying members	6
Other Members and Redundant members	5

26.3.5 Maximum slenderness ratios for leg members, other stressed members and redundant members for compression force shall be as per IS-802.

26.3.6 Minimum distance from hole center to edge shall be 1.5 x bolt diameter. Minimum distance between center to center of holes shall be 2.5 x bolt diameter.

26.3.7 All bolts shall be M16 or higher as per design requirement.

26.3.8 **Step Bolts:** In order to facilitate inspection and maintenance, the structures shall be provided with climbing devices. Each tower shall be provided with M16 step bolts 175mm long spaced not more than 450mm apart, staggered on faces on one leg extending from about 0.5 meters above plinth level to the top of the tower. The step bolt shall conform to IS: 10238.

26.4.0 Design Parameters

All structures shall be designed for the worst combination of dead loads, live loads, wind loads as per code IS:875, seismic forces as per code IS:1893, loads due to deviation of conductor, load due to unbalanced tension in conductor, torsional load due to unbalanced vertical and horizontal forces, erection loads, short circuit forces including “snatch” in the case of bundled conductors etc. Short circuit forces shall be calculated considering a fault level of 40 kA, 50kA, 63kA or as applicable. IEC-60865 may be followed for evaluation of short circuit forces. Lattice type structures are also accepted, however, AEGCL shall have the right to choose any type structure (lattice/pipe) as per requirement during detailed engineering without any price implication.

All Pipe support structures used for supporting equipments shall be designed for the worst combination of dead loads, erection load. Wind load/seismic forces, short circuit forces and operating forces acting on the equipment and associated bus bars as per IS:806. The material specification shall be as per IS: 1161 read in conjunction with IS: 806.

26.4.1 Switchyard structures such as columns, beams and equipment mounting structures shall be designed as per IS 802 but for loading combinations specified hereunder. Computation of wind loading on structural members, conductors, insulators, etc and other parameters shall be as specified in IS 802 except otherwise specified in this Specification.

26.4.2 The switchyard structures shall be designed for following loads considered acting simultaneously:

(i) Wire tension
(ii) Wind Load
(iii) Short Circuit Forces
(iv) Weight of supported wires, insulators, equipment etc and self-weight of structures. An additional load of 3000 N shall be considered acting for weight of lineman and tools. For beams this 3000 N load shall be considered acting at middle of the beam.

26.4.1.3 The design shall be checked for following two loading conditions:

26.4.1.4 The design shall be checked for following two loading conditions:

(A) Normal Conditions (all wires intact)

Under this condition, the loads shall be taken as under:

(i) Wire Tension:- Maximum Wire tension as specified in Clause 39.4.3

(ii) Wind Load:- Loads due to 100% Design Wind Pressure (after accounting for drag coefficient and gust factor) on structures,
wires, insulators, equipment etc. Design wind pressure shall be as per Clause 39.4.2

(iii) Short Circuit Forces: Loading due to a 3 phase short circuit current of 63kA, 50kA, 40 kA and 31.5 kA shall be considered
for 400kV, 220 KV,132 kV and 33 kV respectively subject to minimum of 10% of maximum wire tension as considered in
(i) above.

(iv) Dead Weight:- All dead loads mentioned in Clause 39.4.1.2 (iv) shall be considered. Conductor and shield wire weight shall

L B) BROKEN WIRE CONDITION

Under this condition design shall be checked with all wires broken on one side and load shall be as under:

(i) Wire Tension:- Wire tension for intact wires shall be taken as 100% of Clause 39.4.1.4 (A) (i). For broken wires it shall be
taken as zero.

(ii) Wind Load:-Same wind load as calculated in Clause 39.4.1.4 (A) (ii) shall be considered.

(iii) Short Circuit Forces:- Short circuit forces shall be considered only for intact wires.

(v) Dead Weight: - Same dead load as calculated in Clause 39.4.1.4 (A) (iv) shall be considered.cula

26.4.2 **Design Wind Pressure**

The Design Wind pressure for the purpose of this Specification shall be taken as 793 N/m2. This wind pressure corresponds to Terrain

26.4.3 **Wire Tensions**

For design purpose tension in each power and shield wires shall be taken as under

a. For Power Conductors

(i) 400/220 kV Switchyard:	10000 N for each conductor between Line gantry and Dead-End Tower of Transmission Line.
	8000 N for each Bus Bar conductor and other jumpers/jack buses.
(ii) 132 kV and 33 kV switchyard.	8000 N for each conductor between Line gantries and Dead-End Tower of Transmission Line.
	6000 N for each Bus Bar conductor and other jumpers/jack buses.

b. For Shield Wires

(i) 400kV, 220 KV,132 kV and 33 kV Switchyard.	6000 N for shield wire between Line gantry and Dead End Tower of Transmission Line.
	5000 N for shield wires at other Location.

Note: Structures with earth peak shall assume to have two earth wires for design purpose in broken wire condition.

26.4.4 Spans

Following Spans shall be considered in design of all structures as applicable:-

a). Line gantries (structures to terminate lines):

(i) For 400, 220, 132, Switchyard: 200 Meter, wind span

150 Meter, weight span

(ii) For 33 KV Switchyard: 75 Meter, wind & weight span.

b). All other Structures

(i) For 400 KV Switchyard: 75 Meter, wind & weight span

(ii) For 220 KV Switchyard: 75 Meter, wind & weight span

(iii) For 132 KV Switchyard: 50 Meter, wind & weight span

(vi) For 33 KV Switchyard: 20 Meter, wind & weight span.

26.4.5 Deviation Angle

The design of line gantries shall only be checked for a maximum deviation angle of 300 from normal at center of gantries to Dead End Tower.

26.4.6 Conductors and Shield Wires

A) Following sizes of power conductors if not otherwise specified in the drawings, shall be used for design of structures:

a). For 400 kV switchyard:- As indicated in layout drawings.

b). For 220 kV switchyard:-

(i) ACSR 'MOOSE' conductor (two conductors per phase) for Drop Downs, Jumpers and Connection Between Equipments.

c). For 132 kV switchyard:-

(i) ACSR 'MOOSE' conductor (two conductors per phase) for Drop Downs, Jumpers and Connection Between Equipments.

d). For 33 kV switchyard:-

(i) ACSR 'PANTHER' conductor (One conductors per phase) for Connections between equipments and outgoing feeder till
the 33kV Outgoing feeder Gantry.

B) For protection against direct lightning G.I. wires of size 7/3.66 mm conforming to IS 2241 shall be considered for all switch yards.

Terminal/line take off gantries shall be designed for a minimum conductor tension of 4 metric tonnes per phase for 400kV, 2 metric tonnes per phase for 220kV and 1 metric tonne per phase for 132 kV or as per requirements whichever is higher . The distance between terminal gantry and dead end tower shall be taken as 200 metres for 400/220kV and 100m for 132KV. The design of these terminal gantries shall also be checked considering +/- 30 deg deviation of conductor in both vertical and horizontal planes. For other gantries the structural layout requirements shall be adopted in design.
The beams shall be connected with towers/ columns by bolted joints. Wherever luminaries are proposed to be fixed on gantries, the proper loading for the same shall be considered while designing. Also holes for fixing the brackets for luminaries should be provided wherever required.

Foundation bolts shall be designed for the loads for which the structures are designed. Height of Lightning masts shall be as per approved structure layout and designed for diagonal wind condition. Lightning masts shall be provided with platforms for mounting lighting fixtures and a structural steel ladder within its base up to the level of platform. The ladder shall be provided with protection rings. The platforms shall also have protection railing. The details of lighting fixtures would be as per the approved drawings.

26.5.0 DESIGN DRAWINGS AND DOCUMENTS

As and where asked for the relevant drawings for all the towers, beams and equipment mounting structures shall be furnished by the Contractor to the Employer which shall include structural/erection drawings, shop fabrication drawings, Bill of Materials, foundation working drawings.
The structural/erection drawings, Bill of materials and shop fabrication drawings for all the structures shall be submitted in four copies and will be finally approved by the Employer. The fabrication shall be taken up from the approved shop drawings. The overall responsibility of fabricating structure members correctly lies with the Contractor only and the Contractor shall ensure that all the
members can be fitted while erecting without any undue strain on them.

26.5.1.1 The Contractor shall furnish design, drawing and Bill of Materials and shop manufacturing drawings for every member to the Employer for approval after award of the Contract. The design drawing should indicate not only profile, but section, numbers and sizes of bolts and details of typical joints. In case Employer feels that any design drawing, BOM are to be modified even after its approval, Contractor shall modify the designs & drawings and resubmit the design drawing, BOM as required in the specification.

26.5.1.2 The fabrication drawings to be prepared and furnished by the Contractor shall be based on the design approved by the Employer. These fabrication drawings shall indicate complete details of fabrication and erection including all erection splicing details and typical fabrication splicing details, lacing details, weld sizes and lengths. Bolt details and all customary details in accordance with standard structural engineering practice whether or not given by the Employer. The fabrication drawings shall be submitted to the Employer. Proto shall be made only after approval of fabrication drawings.
26.5.1.3 Such approval shall, however, not relieve the Contractor of his responsibility for the safety of the structure and good connections and any loss or damage occurring due to defective fabrication, design or workmanship shall be borne by the Contractor.
26.5.1.4 The Mass fabrication work shall start only after the final approval to the proto corrected Fabrication drawing is accorded by the Employer.

26.6.0 ACCESSORIES
26.6.1 Step Bolts
Each column/tower shall be provided with step bolts conforming to IS: 10238 of not less than 16mm diameter and 175mm long spaced not more than 450mm apart and extending from 0.5 meters above the plinth level to the top. Each step bolt shall be provided with two nuts on one end to fasten the bolt securely to the tower and button head at the other end to prevent the feet from slipping away. The step bolts shall be capable of withstanding a vertical load not less than 1.5 KN.

26.6.2 **Insulator Strings and Conductor Clamps Attachments**
(i) Double suspension and tension insulator string assemblies (for 400kV, 220kV and 132kV) and Single suspension and tension insulator string assemblies (for 33kV) shall be used for jumpering and connection between the equipments.For the attachment of Suspension Insulator string, a suitable strain plate of sufficient thickness for transferring the load to the tower body shall be provided. To achieve requisite clearances, if the design calls for providing extra D-shackles, link plate etc. before connecting the insulator string the insulator string the same shall be supplied by the Contractor.
(ii) At tension points strain plates of suitable dimensions placed on the beams, shall be provided for taking the hooks or D-shackles of the tension insulator strings. To achieve requisite clearances, if the design calls for providing extra D-shackles, link plate etc. before connecting the insulator string the same shall be supplied by the Contractor.

26.6.3 **Earthwire Clamps Attachment**
i. Suspension Clamp

The detailed drawing shall be submitted by the Contractor for Employer's approval. The Contractor shall also supply U- bolts, Dshackles wherever required.

i. Tension Clamps

Earth-wire peaks of tension towers shall be provided with suitable plates to accommodate the shackle of tension clamps. The contractor shall also supply the U-bolts wherever required and take Employer's approval for details of the attachments before the mass fabrication.

26.7.0 **FABRICATION**

26.7.1 The fabrication of substation steel structures shall be in conformity with the following:

(i). Except where hereinafter modified, details of fabrication shall conform to IS: 802 (Part-II) or the relevant international standards.

(ii). The tower structures shall be accurately fabricated to connect together easily at site without any undue strain on the bolts.

(iii). No angle member shall have the two leg flanges brought together by closing the angle.

(iv). The diameter of the hole shall be equal to the diameter of bolt plus 1.5mm.

(v). The structure shall be designed so that all parts shall be accessible for inspection and cleaning. Drain holes shall be provided at all points where pockets of depression are likely to hold water.

(vi). All identical parts shall be made strictly inter-changeable. All steel sections before any work are done on them shall be carefully levelled, straightened and made true to detailed drawings by methods which will not injure the materials so that when assembled, the adjacent matching surfaces are in close contact throughout. No rough edges shall be permitted in the entire structure.

26.7.2 Drilling and Punching

(i). Before any cutting work is started, all steel sections shall be carefully strengthened and trued by pressure and not by hammering. They shall again be trued after being punched and drilled.

(ii). Holes for bolts shall be' drilled or punched with a jig but drilled holes shall he preferred. The punching may be adopted for thickness up to 16mm. Tolerances regarding punch holes are as follows:

(iii). Holes must be perfectly circular and no tolerances in this respect are permissible.

(iv). The maximum allowable difference in diameter of the holes on the two sides of plates or angle is 0.8mm. i.e. the allowable taper in a punched hole should not exceed 0.8 mm on diameter.

(v). Holes must be square with the plates or angles and have their walls parallel.

(vi). All burrs left by drills or punch shall be removed completely. When the tower members are in position the holes shall be truly opposite to each other. Drilling or reaming to enlarge holes shall not be permitted.

26.7.3 Erection mark

Each individual member shall have erection mark conforming to the component number given to it in the fabrication drawings. The mark shall be marked with marking dies of 16mm size before galvanizing and shall be legible after galvanizing.

26.8 FOUNDATION BOLTS

26.8.1 Foundation bolts for the towers and equipment supporting structures and elsewhere shall be embedded in first stage concrete while the foundation is cast. The Contractor shall ensure the proper alignment of these bolts to match the holes in the base plate.

26.8.2 The Contractor shall be responsible for the correct alignment and levelling of all steel work on site to ensure that the towers/structures are plumb.

26.8.3 All foundation bolts for lattice structure, pipe structure is to be supplied by the Contractor.

26.8.4 All foundation bolts shall be fully galvanised so as to achieve 0.61 kg. per Sq.m. of Zinc Coating as per specifications.

26.8.5 All foundation bolts shall conform to IS 5624 but the material, however shall be MS conforming to IS: 2062.

26.9.0 **GALVANIZING AND PAINTING**

26.9.1 Galvanising of the various members of the structures shall be done only after all works of sawing, shearing, drilling, filing, bending and matching are completed. Galvanising shall be done by the hot dip process as recommended in IS: 2629 or other such authoritative international standards and shall produce a smooth, clean and uniform coating of not less than 610 gm per square meter. The preparation for galvanising and the galvanising process itself must not affect adversely the mechanical properties of the treated materials.

26.9.2 All assembly bolts shall be thoroughly hot dip galvanized after threading. Threads shall be of a depth sufficient to allow for the galvanized coating, which must not be excessive at the root of the threads, so that the nut shall turn easily on the completed bolts without excessive looseness. The nut threads shall not be galvanized, but oiled only.

26.9.3 The outside surface shall be galvanised. Sample of galvanised materials shall be supplied to the galvanising test set out in IS 729 or other such authoritative international standards.

26.10 **EARTHING**

39.10.1 To keep provision in the structures for earthing, holes shall be drilled on two diagonally opposite legs of the towers/columns/mounting structures. The holes shall be suitable for bolting GI strips of size mentioned elsewhere in this specification (Vol II) and shall be such that the lower hole is about 350 mm above the ground level, clear of the concrete muffing, for connecting the earthing strip.

26.11 TEST AND TEST CERTIFICATE

26.11.1 Each consignment ready for transportation shall be offered to AEGCL for inspection before dispatch giving a minimum time of not less than 30 days. Samples of fabricated structure materials shall be subjected to following tests: -

a. Steel: The structural steel shall conform to IS 226 and IS 8500, BS 4360-1068 or ISO / R 630 other such authoritative international standards. Manufacturer's test certificate shall be submitted for all used steel.

b. Galvanising: The galvanising shall be as per IS 2633 or BS 729 other such authoritative international standards. Zinc coating over the galvanised surfaces shall not be less than 610 gm per square meter.

c. Bolts and nuts: Manufacturer's test certificate as per standard practice shall be submitted.

26.11.2 Test at Contractor's Premises

26.11.2.1 The contractor shall fabricate one specimen structure of each type as soon as possible after placement of order and before starting the bulk fabrication of the structures ordered. It shall be assembled on a foundation as nearly similar as practicable to site and tested with suitable test loads as per specified broken wire condition, multiplied by the corresponding factor of safety to ensure that the design and fabrication complies with the requirements. Each structure shall be capable of withstanding the above-mentioned tests without any injury or any permanent deflection at any part. If any member is found to be weak or damaged the design should be suitably modified and the tower re-tested.

26.11.2.2 After the first lot of the structures manufactured, the members forming one structure of each type shall be selected at random from the lots of similar member and assembled in exactly the same manner as to be done at site. The structure then shall be set on foundation as nearly similar as practicable to site and tested with equivalent test load for which the structure has been designed.

26.11.2.3 No structure or any member thereof, which failed under the test shall be supplied.

26.12 MODE OF MEASUREMENT

26.12.1.1 The measurement of all lattice and pipe structures for towers, beams, equipment support structure etc. shall be made in numbers for each type of structures. This will include foundation bolts and nuts and therefore no separate payment shall be made for the same. The unit rate quoted for each type of structure shall be inclusive of supply, fabrication, galvanizing, erection, nuts, bolts, wastages etc. complete. Nothing extra shall be payable for substitution necessitated due to non-availability of section. Nothing extra shall be payable for modifications or steel added to suit the contractors fixing arrangements for accessories etc.

CHAPTER – 27: SPECIFICATION FOR ACDB

27.1 SCOPE :

This specification covers design, manufacture, assembly, testing, at the manufacturer's works, supply, and delivery erection and commissioning of indoor type 415 Volts AC switch boards for the sub-stations as per approved schemes.

This also includes design, supply, laying and termination of XLPE insulated armoured power and control cables required for distribution of AC auxiliary power at different points of switchyard, control room building, colony and utility area, fire fighting pump house etc. for various purpose including Air conditioning system at control room, conference room and other places if mentioned in the technical specification of Air conditioning.

27.2 STANDARDS :

The equipment covered by this specification shall, unless otherwise specified, be in accordance with, relevant IS specification. The degree of protection shall not be less than IP-54 and IP-42 as per IS:2447 in case of bus bar chambers where continuous bus bar rating exceeds 1000 Amps.

27.3 DEVIATION :

Normally the offer should be as per Technical Specification without any deviation. . In case of any deviation taken against technical specification same are to be submitted in a separate deviation sheet for review of AEGCL.

27.4 MODIFICATION :

If any modification felt necessary to improve performance, efficiency and utility of equipment, the same must be mentioned in the 'Modification schedule' with reasons duly supported by documentary evidences and advantages. Such modifications suggested may or may not be accepted, but the same must be submitted along with Pre-Bid Queries. The modifications not mentioned in Schedule will not be considered.

27.5 DESIGN CRITERIA :

i) In case of 400KV sub-station, AC source shall be supplied separately from LT side of 2 numbers,1000KVA, 3/0.415KVstationservicetransformersthroughcable as per tender auxiliary SLD.

ii) Two numbers 400 V/ 400 V Lighting Transformer with voltage variation arrangement atprimary side (in Off-load condition) in the range of ±5% in steps of 2.5%, shall be underscope of the bidder for supply, Erection, Testing & Commissioning for connection of Main of MainACDBwiththeMLDBpanel.RatingofLightingTransformersshallbeminimum100KV Afor400/220/132/33KVsub-station. **One number, 100kVA shall**

be provided for connection to ELDB.However, rating may increase as per actual requirement keeping20%sparecapacity,which shall bewithinthescope of bidder.

iii) The maximum loss component shall be guided as per relevant IS / IEC.

THERE SHALL BE FOLLOWING PANELS DESIGNATED AS

a) MAIN ACDB – 2 Numbers
b) Sub ACDB – 2 Numbers
C) Main Lighting Distribution Board (MLDB) – 1 Number
D) Emergency Lighting Distribution Board (ELDB) – 1 NUMBER
E) HVAC DB – 1 NUMBER
F) MCB DB – 1 NUMBER

All the above AC Panels shall be interconnected as per scheme layout.

iv) **<u>Main ACDB:</u>** <u>(415V)</u>

Both the main AC Distribution board shall consist of the following items but not limited to this extent, within the scope of supply by Contractor with erection, Testing & Commissioning.

- 2000 A,4P Air Circuit Breaker and CT (of requisite rating) for 33/0.415 V station service transformers as INCOMER I for ACDB 1
- 2000 A,4P Air Circuit Breaker and CT (of requisite rating) for 33/0.415 V station service transformers as INCOMER II for ACDB 2
- 2 numbers 2000A, 4P Air Circuit Breaker along with 2 sets of CTs (of requisite rating) as Bus- coupler
- Ammeters, voltmeters, energy meters, frequency meters, protective relays,fuses and all other equipment etc. required for complete operation shall be provided in the incomers.
- PT shall be provided to measure the bus voltage alongwith relays.
- Current, voltage and energy measurement shall be provided to SAS.
- Bus bar shall be of copper with bus bar rating as 2000A, 25kA for 3 sec with adequate current density. Earth bus bar shall also be of copper.
- Interlocks **with DG set** shall be provided as per requirement and the same shall be decided during detailed engineering.
- The cable from station service to Main ACDB shall be 1.1kV, 1C, 1000sqmm, 2 runs for each phase and 1 run for neutral. The size of the cable may vary during detailed engineering.
- All outgoing feeders shall be provided with ACB and MCCBs as required.

v) **<u>Sub ACDB: (415 V)</u>**

Incomer

1. Incomer from ACDB 1 to sub ACDB 1 and Incomer from ACDB 2 to sub ACDB 2 through MCCB and CT (of requisite rating)
2. Bus coupling between sub ACDB 1 and sub ACDB 2 through 2 nos MCCB and 2 nos CT (of requisite rating)
3. DG incomer (with AMF Panel) shall be connected to Sub ACDB-1 and Sub-ACDB

-2

4. Ammeters, voltmeters, energy meters, frequency meters, protective relays **(SC, O/L,E/F)**, fuses and all other equipment etc. required for complete operation shall be provided in the incomers.
5. PT shall be provided to measure the bus voltage alongwith relays.
6. Current, voltage and energy measurement shall be provided to SAS.
7. Bus bar shall be of copper with adequate bus bar rating with adequate current density. Earth bus bar shall also be of copper.
8. Interlocks shall be provided as per requirement and the same shall be decided during detailed engineering.
9. For all motor feeders shall be provided with all required protective relays.
10. All outgoing feeders shall be provided with MCCBs.

vi) **MLDB**:

The MLDB (Main Lighting Distribution Board) shall consist of –

- Two nos. 415 V Air Circuit Breaker as Incomer I & Incomer II from Main ACDB (through 2 nos. of Lighting transformers 400V / 400V, delta / star, Z% ~ 4.5, air cooled, dry type) and one no Air Circuit Breaker as Bus –Sectionaliser.
- Current, voltage and energy measurement shall be provided to SAS.
- Ammeters, voltmeters, energy meters, frequency meters, protective relays, fuses and all other equipments etc. required for complete operation shall be provided in the incomers.
- Bus bar shall be of copper with adequate bus bar rating, with adequate current density. Earth bus bar shall also be of copper.
- Interlocks shall be provided as per requirement and the same shall be decided during detailed engineering.
- All outgoing feeders shall be provided with MCCBs.

vii) **ELDB:** Emergency Lighting Distribution Boards

- Two nos. 415 V MCCB as Incomer I & Incomer II from Main MLDB and one no MCCB as Bus–Sectionaliser. One Lighting transformer shall be provided for ELDB (415/415V, 50KVA).
- Current, voltage and energy measurement shall be provided to SAS.
- Ammeters, voltmeters, energy meters, frequency meters, protective relays, fuses and all other equipments etc. required for complete operation shall be provided in the incomers.
- Bus bar shall be of copper with adequate bus bar rating, with adequate current density. Earth bus bar shall also be of copper.
- Interlocks shall be provided as per requirement and the same shall be decided during detailed engineering.
- All outgoing feeders shall be provided with MCCBs.

27.6 INTERLOCK LOGIC :

Electrical & Mechanical interlocking arrangement with Trip logic between the air circuit breakers **of sub ACDB 1 and sub ACDB 2 and DG** are tobe provided.

A. Interlocking of Incomer I & Incomer II with Bus Section Breaker:

1. Under normal condition (i.e. when supply is available through both the incomers), incomers I & II shall be in closed condition, Closing of Bus Coupler breaker shall be prohibited.

2. In case of failure of either of the sources, the incomer of that source shall trip through Under-Voltage relay and Bus coupler shall be allowed to close. After restoration, the respective incomer shall be allowed to close only after opening of Bus coupler breaker.

3. The above electrical interlock should be done through Breaker auxiliary contact switch.

4. Any other interlock logic shall be decided during detailed engineering.

5. A truth table and a load list shall be provided for all the distribution boards.

B. <u>Interlocking of Incomer I & Incomer II of Sub-ACDB with DG-Incomer Breaker:</u>

1. Under normal condition (i.e. when supply is available through both the incomers), incomersI & II shall be in closed condition, Closing of DG-Incomer breaker shallbe prohibited.

2. In case of failure of either of the sources, the incomer of that source shall trip through Under-Voltage relay and Bus coupler shall be allowed to close, but Closing of DG-Incomer breaker shall be prohibited.

3. In case of failure of supply of both the incomers, both the incomer alongwith bus coupler shall trip through Under- Voltage relay and DG set breaker shall be allowed to switch on. After restoration, the incomer breakers shall be allowed to close only after opening of DG set breaker. Time delay relay shall be used to obtain the interlock logic.

4. The above electrical interlock should be done through Breaker auxiliary contact switches.

<u>The interlock schemes may be modified during detailed engineering as per AEGCLs requirement and ease of operation.</u>

27.7 TYPICAL FEEDER DISTRIBUTION OF SUBSTATION:

A. <u>GENERAL</u> (Exact Quantity will be finalised at the time of Detailed Engineering and within the scope of bidder. Generally, **MCCB shall be considered**. In case of exigency, SFU can be used by taking prior written approval from AEGCL approving engineer.): Cable sizes shall be considered as per the load.

1. INTERCHANGEABILITY :

All similar material and movable parts shall be interchangeable with each other. Such as the breakers, switches, contactors etc. shall be easily removable as a complete unit from the switch boards and shall be capable of being put into similar position in other switch boards for performing identical function.

2. CONSTRUCTION :

The switch boards shall be of multi-cubicle or multi box factory-built air-insulated type, fully enclosed with doors for access to the interior. 3.00 mm. thick steel sheet shall be used for the fabrication of the panels. Boards shall be easily extendible on both sides, by the addition of the vertical section after removing the end covers.

The complete panels shall not be more than 2450 mm. high with the channel base and the depth shall be preferably within 1000 mm. wide measured from rear to front faces. The working height shall be minimum 450 mm. to maximum 2000 mm. The width of the panel shall depend upon the no. of circuits to be accommodated.

All boards shall be divided into distinct vertical sections each comprising of :

(i) A completely enclosed bus bar compartment for running horizontal and vertical COPPER bus bars. Bus bar chamber shall be completely enclosed with metallicportions. Bolted covers shall be provided for access to horizontal and vertical bus bars and all joints for repair and maintenance, which shall be feasible without disturbing feeder compartment. Proper ventilation arrangement shall have to be arranged and that shall be decided by the purchaser at the time of approval of drawings

(ii) Completely enclosed switchgear compartments one for each circuit for housing Air circuit breaker or SFU or MCB or MCCB or motor starter.

(iii) A compartment for power and control cable. Door of compartment shall be hinged. Cable compartment shall have no communication with bus bar chamber.

(iv) A compartment for relays and other control devices associated with a circuit breaker. The panels shall be designed to facilitate cable entry from the bottom through entryholes of removable gland plates provided at the bottom of the cubicle. All the accessories required for terminations of cables in the ACDB such as cable gland,terminal block etc. shall be within the scope of supply.

(v) Doors shall have pad locking facilities.

After isolation of power and control circuit connections it shall be possible to safely carry out maintenance in a compartment with the bus bar and adjacent circuit live. Necessary shrouding arrangement shall be provided for this purpose over the cable terminations located in cable alley.

In case of providing two incomers air circuit breaker in the same vertical section, insulating barriers and shroud shall be provided in the rear cable compartment in order to avoid accidental touch with live parts of one circuit when working on the other circuit.

The connections from bus bars to main switch shall be fully insulated/shrouded and securely bolted. The partition between the feeder compartment and cable alley may be non-metallic and shall allow cables cores with lugs to be easily inserted in the feeder compartment for termination.

The switch board shall be dust proof, vermin proof, rodent proof and suitable for use in tropical climate. All ventilating louvers and holes shall be covered with fine wire mesh from inside. Necessary pre-treatmentof the panel surface is to be done by seven tank process followed by 2 coats of polyurethane/enamel paint. The colour of the exterior of the panel shall be **RAL-7032** as that of the main control and relay panel. The colour of the interior panel should be as to provide a colour contrasting background for the wiring Inside the cubicle.

The switchboards shall be mounted on channel and shall be complete with channel bottom plates made of structural steel, grouting bolts, earthing bolts, washers, cable glands etc.

Both the single and three phase switches as well as the fuse terminals provided on the panel shall be of best quality and easy in operation.

The tentative entries of power and control cable shall be from bottom.

Adapter panels and dummy panels required to meet the various bus bar arrangements andlayout required shall be included in Bidder's scope of works.

All modules shall be fixed type except air circuit breaker module which shall be draw out type. All disconnecting contacts for power circuits shall be of robust design and fully self-aligning.

Fixed and moving contacts of the power draw out contact system shall be silver-plated andboth fixed and moving contacts shall be replaceable. Silver plating shall not be less than 25 microns.

All Distribution Boards shall be single front type.

All single front board shall be provided with removable bolted covers at the rear. The coversshall be provided with danger levels.

Sheet steel barriers shall be provided between two adjacent panels running to the full heightof the switch board, except for the horizontal bus bar compartment.

A. POWER BUS BARS AND INSULATORS

Bus bars shall be of Copper, liberally sized for the specified continuous current rating as per approved scheme and short circuit current rating of 50 KA (rms) for 3 sec. Necessary precaution shall be taken to avoid bimetallic action. Means shall be provided for identifying various phases of bus bars by red, yellow and blue paint. The cross section of the bus bars shall be uniform through out the length of switch gear.

Bus support shall be of arc resistant, non-tracking, low absorption type installations of highimpact strength to withstand normal as well as fault condition stresses.

i. EARTH BUS : A copper earthing shall be provided at the bottom of each panel and shall extend through out the length of switchboard. It shall be welded/bolted to the frame work of each panel and breaker earthing contact bar. Vertical bus shall be provided in each vertical section which shall in turn be bolted/welded to main horizontal ground bus. Bimetallic connection shall be provided to connect the earth bus with the main substation earth bus.

ii. The earth bus shall have sufficient cross section to carry momentary short circuit and short time fault currents to earth bus without exceeding the allowable temperature rise.(Preferably 65x12 or higher as per calculation)

iii. The horizontal earth bus shall be projected out of the switch board ends and shall have pre-drilled holes for bolted connection between this bus to sub-station earthing conductor. A joint spaced and taps to earth bus shall be made through at least two bolts.

iv. All non-current metal works of the switch board shall be effectively bonded to the earth bus.

B. AIR CIRCUIT BREAKERS : (For two incomers and bus sectionaliser of ACDB and DG)

i) Incoming and Bus sectionalizer air circuit breaker shall be four pole air break horizontal draw out type and shall have inherent fault making and breaking capacities as per requirement. All the poles of circuit breakers shall open and close simultaneously. The neutral pole shall be 100% rated.

ii) Circuit breakers shall be mounted along with it operating mechanism on a wheeled carriage. Suitable guides shall be provided to minimise misalignment of the breaker.

iii) There shall be 'Service', 'Test' 'ISOLATED' and 'MAINTENANCE' positions for the breakers. In 'Test' position the circuit breaker shall be capable of being tested for operation without energising the power circuits i.e. the power Contacts shall be disconnected while the Control circuits shall remain undisturbed. Locking facilities shall be provided so as to prevent movement of the circuit breaker from the 'SERVICE', 'TEST'. It shall be possible to close the door in 'TEST' position.

iv) There should be provision for locking the air circuit breaker in 'ISOLATED' position to achieve mechanical interlocking with Incomer & Bus sectionalizer Air Circuit Breakers.

v) All circuit breakers shall be provided with 8 NO and 8 NC potentially free auxiliary contacts with additional 20% spare. These contacts shall be in addition to those required for internal mechanism of the breaker. Separate limit switches each having required number of contacts shall be provided in both 'SERVICE' & 'TEST' position of the breaker. All contacts shall be rated for making continuously carrying and breaking 10 Amps at 240 V AC and 2 Amp at 220 V DC.

vi) Suitable mechanical indications shall be provided on all circuit breakers to show 'OPEN', 'CLOSE', 'SERVICE', 'TEST', ISOLATED and 'SPRING CHARGED' positions.

vii) Movement of a circuit breaker between SERVICE AND TEST positions shall not be possible unless it is in OPEN position. Racking interlock for this shall be provided.

viii) Closing of a circuit breaker shall not be possible unless it is in SERVICE, TEST POSITION or in FULLY WITHDRAWN POSITION.

ix) Circuit breaker cubicles shall be provided with safety shutters operated automatically by the movement of the circuit breaker carriage to cover the stationary isolated contacts when the breaker is withdrawn. It shall however, be possible to open the shutters intentionally, against spring pressure for testing purpose.

x) A breaker of particular rating shall be prevented from insertion in a cubicle of a different rating. The ACB's shall have rating error preventor to achieve this.

xi) Circuit breakers shall be provided with electrical anti-pumping and trip free feature even if mechanical anti-pumping feature is provided.

xii) Mechanical tripping shall be possible by means of front mounted RED 'Trip' push-button. In case of electrically operated breakers these push-buttons shall be shrouded to prevent accidental operation.

xiii) Power operated mechanism shall be provided with a universal motor suitable for operation 220V DC Control supply with voltage variation from 85% to 110% rated voltage. Motor insulation shall be class 'E' or better.

xiv) Once the closing springs are discharged, after the one closing operation of circuit breaker, it shall automatically initiate, recharging of the spring. The motor shall be such that it requires not more than 30 seconds for fully charging the closing spring.

xv) The mechanism shall be such that as long as power is available to the motor, a continuous sequence of closing and opening operations shall be possible. After failure of power supply at least one open-close-open operation shall be possible.

xvi) Provision shall be made for emergency manual charging and as soon as this manual charging handle is coupled, the motor shall automatically get mechanically decoupled.

xvii) All circuit breakers shall be provided with closing and 2 trip coils. The closing coils shall operate correctly at all values of Voltage between 85% to 110% at rated control voltage. The trip coils shall operate satisfactorily under all values of supply voltage between 70% to 110% of rated control voltage Trip ckt supervision shall be provided for both the trip coils.

xviii) The door of the circuit breaker compartment shall be interlocked so that (1) door cannot be opened while the breaker is in closed position and (2) when the door is open the breaker cannot be closed. However, facility to defeat this interlock shall be provided for testing purpose.

i) Provision for mechanical closing of the breaker only in 'TEST' and 'WITHDRAWN' positions shall be made.

ii) Air Circuit Breakers shall be from one of the following manufacturer's complying with technical specification & relevant IS & IEC

- M/s Siemens
- M/s L & T
- M/s ABB
- M/s Schneider
- M/s GE

C. SWITCH FUSE UNIT (SFU), MOULDED CASE CIRCUIT BREAKER (MCCB) AND (MCB)

i) SFU / MCCB shall be 4 pole /2 pole, capable of safely breaking the fault current of the associated feeder. Rating of SFU / MCCB's shall be chosen by the contractor depending upon requirement of outgoing feeders and **as decided in detailed engineering stage and shall be subject to approval of AEGCL.**

ii) All the SFU / MCCB shall be flush mounted on AC Distribution boards provided with Rotary operating handle with clear ON-OFF trip indication.

iii) MCCBs shall be provided with thermo-magnetic type release for over current and short circuit protection. The o/c setting shall be adjustable type. The s/c settings shall be adjustable type.

iv) The setting range of thermal release and breaking capacity of MCCBs are to be specified and shall conform to system requirement. MCCB Knob shall indicate the true position of the equipment. MCCBs shall conform to relevant Indian Standard IS : 13947 Part 2 and shall be of P2 duty.

v) AC switch board shall be installed in a separate ACDB room other than control room for 400/220/132/33KV S/stn. For tripping of any of the outgoing feeder, visual and audible alarm arrangement shall be provided in the AC Board. However arrangement has to be made for getting audible alarm at the control room for the knowledge of the operator regarding tripping of the outgoing feeders. Necessary arrangement shall also be provided for acceptance and resetting of the audible alarm. In case of tripping of Incoming feeder breaker or Bus sectionalizing breaker, arrangement of both audible and visual annunciation shall be made both at AC Board as well in Control room. Acceptance and resetting arrangement is to be provided.

vi) Interlocks shall be provided such that it is possible to open the cubicle door only when the SFU / MCCB/MCB is in 'OFF' position and to close the SFU / MCCB/MCB when the door is closed.

vii) Miniature Circuit Breaker (MCB) shall conform to IEC:898-1987 and IS:8828.

viii) SFU, MCCB & MCB shall be from one of the following manufacturer's complying with technicalspecification & relevant IS & IEC

a) M/s Siemens
b) M/s L & T
c) M/s ABB
d) M/s Schneider
e) M/s GE

In this project, MCCBs and MCBs shall only be used. MCBs shall be used below 15A.

D. CONTROL AND SELECTOR SWITCHES :

a) Control and Selector switches shall be rotary type with escutcheon plates clearly marked to show the junction and positions. Switches shall be of sturdy construction suitable for making on panel front.

b) Voltmeter selector switches shall have four stay put position with adequate no. ofcontacts for 3-phase 4-wire system. These shall be oval handles. .

c) Contacts of the switches shall be spring assisted and shall be of suitable material forgiving long trouble free services.

d) Contact ratings shall be at least the followings :

(i) Make and carry continuously : 10 Amp.

(ii) Breaking current at 240VAC :4KA (at 0.3 p.f.lagging)

E. AIR BREAK SWITCHES :

a) Air breaker switch shall be of heavy duty, single throw group operated, load break, faultmake type complying IS:4046.

b) Switch operating handles shall be provided with pad locking facilities to lock them in 'OFF' position.

c) All switches shall be adequately rated so as to be fully protected by the associated fuses during all abnormal conditions such as over load, locked motor, short circuit etc.

d) Interlock shall be provided so that cubicle door can only be opened when the switch is in 'OFF' position and to close the switch only when the door is closed. However, suitable means shall also be provided to intentionally defeat the interlocks as mentioned above.

e) Switches and fuses MCCB/MCB for AC control supply and heater supply wherever required shall be mounted inside the cubicles.

F. INDICATING LAMPS OF CONTROL SWITCHES :

Indicating lamps shall be of the panel mounting cluster LED type. The lamps shall have suitable size plates marked with its function, wherever necessary.

Lamps shall have translucent lamp covers of the following colours.

RED	Breaker Closed.
GREEN	Breaker Open
WHITE	Breaker Auto-Trip
BLUE	For all healthy condition. (e.g. Control supply and also for“SPRING CHARGED” and “TRIP CIRCUIT HEALTHY”)
AMBER	For all alarm conditions (e.g. overload).

Separate indication lamps for ‘SERVICE’, ISOLATED and‘TEST’ positions shall be provided.

G. SPACE HEATERS :

Space heaters shall be provided for preventing harmful moisture condensation in all the AC Boards. The space heaters shall be suitable for continuous operation on 240 V AC,50 HZ,1-phase supply and shall be automatically controlled by thermostats. Necessary isolating switches and fuses shall also be provided.

H. INTERNAL WIRING AND TERMINAL BLOCK :

(a) All switch boards shall be supplied completely wired internally upto the terminal blocks.

(b) All inter cubicle and inter panel wiring and connections between panel of same switch board including all bus wiring for AC and DC supplies shall be provided by the contractor.

(c) All internal wiring shall be carried out with XLPE insulated, stranded copper conductor, 1.1kV, single core, 2.5 sq. mm. or larger stranded copper wires. CT Ckts. shall be wired with 4 sq. mm. voltage grade and insulation of copper wires shall be same as above. Voltage drop shall be allowed only in the tune of 3% at the remote end of the longest outgoing feeder from the AC Panel board and 15% drop in case of starting of motor of the remote end.

(d) All wiring shall be properly supported, neatly bunched, readily accessible and securely connected to equipment terminals and terminal blocks.

(e) Each wire shall be identified at both ends and shall be properly tagged and ferruled in compliance with approved drawings. Wires shall not be spliced or tapped between terminal points.

(f) Terminal blocks shall be of 1100 V grade 'Elmex/connect well' make and have continuous rating to carry the maximum expected current on the terminals. The terminal blocks shall be fully enclosed with removable covers of transparent, non-deteriorating type plastic material. Insulating barrier shall be provided between the terminal. The terminal blocks shall have locking arrangement to prevent its escape from the rails. **30% spare terminals are to be provided on all terminal blocks.**

(g) Terminal blocks for CT secondary leads shall be provided with test links and isolating facilities. CT secondary leads shall be provided with short circuiting and earthing facilities. Jam nut should be provided with shorting link.

(h) All terminal blocks shall be normally suitable for terminating on each side, two (2) nos. of
2.5 mm. sq. size stranded copper conductor. However, terminal blocks to be used inconjunctive with CT shall be suitable for terminating 4 sq. mm. single core Copper wires.

(i) All terminals **shall be ring type** and numbered for identification and grouped according to the function. Engraved white on-black labels shall be provided on the terminal blocks.

(j) Terminal blocks shall be arranged with at least **200 mm**. clearance between two sets of terminal block. The minimum clearance between the first row of terminal block and the associated cable gland plate shall be 250mm.

I. POWER CABLE TERMINATIONS :

(a) Cable termination compartment and arrangement for power cables shall be suitable for stranded copper Conductor, armoured XLPE insulated and sheathed 4 / 3.5 -core, 1100V grade.

(b) All necessary cable terminating accessories such as Gland plates, supporting clamps and brackets, power cable lugs, hardware etc. shall be provided by the contractor to suit the final cable sizes.

(c) The gland plate shall be of removable type and shall cover the entire cable alley. Bidder shall also ensure that sufficient space is provided for all cable termination.

J. GROUNDING :

An copper strip ground bus rated to carry maximum fault current for the specified duration shall be provided along the entire length of the distribution board.

Each casing of the equipments, relays, instruments provided in the board shall be connected directly to the ground bus by independent stranded copper wires of not less than 2.5 sq. mm.The earth bus shall have sufficient cross-section to carry the momentary short circuit and short time fault currents to earth without exceeding the allowable temperature rise. The ground bus shall be brought out to two terminals at the two ends of the switch board for Connecting G.S. Flat of 65×12mm for all voltage classes. CT & PT secondary neutral pointshall be at one place only on the terminal block. Such earthing shall be made through links.

K. TROPICAL FINISH :

All electrical equipment, accessories and insulation of wiring shall have fungus protection involving special treatment on insulation and metal against fungus, insect and corrosion.

L. INSULATION :

The insulation at any point in the distribution board shall be of 1.1 KV grade.

27.8 ASSOCIATED EQUIPMNET AND ACCESSORIES:

A. CABLE GLANDS :

All feeders shall be provided with suitable dust tight screwed brass **double compression cable** glands conforming to the relevant IS standard.

Gland shall project above the gland plate. Terminating cables shall be armoured and the armour rods shall be connected to earth bar.

B. METERS :

The accuracy class of Electronic type KWH meter shall be 0.2. One KWH meter of 3-phase, 4-wire type shall be flush mounted on each of the incoming breaker compartments of **Main ACDB/DG**, Ammeter and voltmeter shall be of 72*144sq.mm and of flush mounting digital type with accuracy +/- 1% of full scale. The meters shall conform to the appropriate IS specification. All circuitsof the meters shall be capable of withstanding 20% overload for a period of at least 8 hours.Three no. digital Ammeter and one no digital Voltmeter shall be provided for each incoming CB’s of Main ACDB/Sub ACDB’s with voltmeter selectors with and ammeter selector switch.

C. NUMERICAL RELAYS :

All the protections shall be of numerical type (shall be as per make list) and supported by Test Certificates from Govt. recognized Test house and performance certificates from Govt./Power Utilities.
The relay shall have –

a) Minimum two characteristics, one IDMT of 3 sec. and the other one of definite time characteristic and the same should be site selectable.

b) Wide range of time and current setting in very small steps without sacrificing the relay characteristics.

c) Tripping indication for different type of faults until reset by the operator.

d) Continuous self supervision along with self diagnostic feature for faults within the relay and the relay should have potential free 'Change over Contact' for annunciation in the eventof internal failure.

e) Output contacts having sufficient current rating to directly energise trip coil of circuitbreaker.

f) LED indication facility for visual annunciation of different type of faults including phaseidentification.

g) Individually site selectable binary Output and Input and latching option for binary Output.

Motor starters shall be provided with ambient temp. compensated, time lagged, hand reset type over load relays with adjustable settings ranges to suit motor ratings. These relays shall have separate black coloured hand reset push button mounted on compartment door and shall have at least one changeover contact.

D. INSTRUMENT TRANSFORMER (FOR 400/220/132/33KV SUBSTATION) :

All current and voltage transformers shall be completely encapsulated cast resin insulated wound type suitable for continuous operation at the temperature prevailing inside the switch gear enclosures, when the switch board is operating at its rated condition and the outside ambient temperature is 50^{o}C.

All instrument transformers shall be able to withstand the thermal and mechanical stresses resulting from the maximum short circuit.

All instrument transformers shall have clear indelible polarity markings.

The insulation level of C.T shall be suitable for 1.1 KV grade. C.T. for 400KV portion shall be 2500/1A, 3 core type of which one core for metering and second core for protection. The third core of the C.T shall be used for REF protection and particulars shall be 20 VA, 5P20. The REF relay shall be mounted in the 33 KV C & R panel and the respective LT side phase C.T cores for REF protection shall be terminated to the terminal block of the AC panel.

All voltage transformers shall have readily accessible HRC current limiting fuses on both primary and secondary sides.

27.9 NAMEPLATES AND LABELS :

ACDB shall be provided with prominent, engraved **anodized** identification plates. The module identification plate shall clearly give feeder number and feeder designation. For single front switchboards, similar panel and board identification labels shall be provided at the rear also.

All name plates shall be non-rusting metal or 3-ply lamicold with white engraved lettering on black base ground. Suitable plastic sticker labels shall be provided for easy identification of all equipments, located inside the panel / module. These labels shall be positioned so as to be clearly visible and shall give device number as mentioned in the module wiring.

27.10PACKING AND DESPATCH :

All equipments shall have to be dispatched suitably and securely packed in wooden crates, suitable for handling during transit by rail and / or road.

27.11 CONTRACT DRAWING & CATALOGUE :

A. After placement of Letter of Award **four (**4) copies of following drawings, GTP and literature shall be submitted to the AEGCL for approval :

i) Single line diagram of each AC Board.

ii) General Arrangementdrawingshowingdimensionsoffrontandrearviewofeachswitch board with relay instruments and other devices position marked. Height, width, depth and ground fixing arrangement shall have to be indicated.

iii) Schematic wiring diagram for each switchboard.

iv) Catalogue on each type of circuit breaker, MCCB, switches, fuse, relays, meters etc. offered. The list of drawing shall be furnished in the schedule attached herein.

27.12 TESTS AT MANUFACTURER'S WORKS AND TEST CERTIFICATES :

A. Acceptance and routine test at manufacturer's works shall be carried out on each AC Board as per stipulation of relevant Indian Standard. The entire cost of acceptance and routine tests are to be carried out shall be treated as included in the quoted price of allDistribution Board.

All the acceptance and routine tests shall be carried out in presence of representative of AEGCL. Three (3) copies of test reports shall be submitted to the AEGCL for approval anddistribution to site.

B. The Contractor shall give at least 15 (fifteen) days advance notice intimating the actualdate of inspection and details of all tests that are to be carried out.

27.13 GUARANTEE :

Electrical characteristic shall be guaranteed by the bidder. In case of failure of materials to meet the guarantee, AEGCL shall have right to reject the material. Guaranteed Technical Particulars are to be submitted by successful bidder during detailed engineering along with submitted drawings/documents. However format for submission of GTP shall be handed over to intending bidders at the time of Sale of tender document.

SPECIFIC TECHNICAL PARAMETERS OF AC DISTRIBUTION BOARDS

The following particulars are to be complied with :

SL NO	DESCRIPTION		TECHNICAL PARAMETERS
1.	DIMENSIONS :		
	i)	Height of complete panel (mm)	2450 (Max.)
	ii)	Working height (mm)	450 (Min.) to 2000 (Max.)
	iii)	Depth (mm)	1000 (Max.) for outgoing panel & 1500(Max) for Air C.B. panel.
	iv)	Length of the panel (mm)	As per requirement
2.	Sheet steel thickness of Panel (mm)		3 (Min.)
3.	Insulation Level of Equipments and Wiring (KV)		1.1
4.	Minimum Rating of Fuses (Amps.)		Not less than 16
5.	Spring operated Air Circuit Breaker/ SFU / MCCBfault current breaking Capacity (KA)		50
6.	Voltmeter Range / Rating (Volts)		0 to 500
7.	Ammeter Range with Current Transformer (Amps)		As per requirement. Shall be decided during detailed engineering
8.	LT AC AIR CIRCUIT BREAKER :		
	i)	System Voltage	400 V AC +/- 10%
	ii)	Insulation Voltage	1.1 KV1.2
	iii)	Rated Imp withstand voltage of mainCktUimp	8 KV
	iv)	Rated Imp withstand voltage of AuxCktUimp	4 KV
	v)	Ambient Temperature	50^{o}C
	vi)	Rated frequency	50 Hz
	vii)	Rated Continuous Current at 50^{o}C	2000A for 1MVA transformer
	viii)	a) Ultimate Short Ckt Breaking CapacityIcu	50KA
		b) Service Short Ckt Breaking CapacityIcs	100% of Icu
		c) Withstand Short Ckt BreakingCapacity Icw	50 KA for 1 Sec
		d) Rated Making Capacity Icm	105 KA
	ix)	Utilisation Category	B
	x)	Suitable Isolation	Yes

	xi)	No. of Poles	4 Pole
	xii)	a) Opening Time	40-60 ms
		b) Closing Time	60-80 ms
	xiii)	Type of Breaker	Electrical Draw Out
	xiv)	a) Spring Charging Voltage	230 V AC/220V DC
		b) Permissible Variation in Voltage	85% to 110%
		c) Spring Charging Time	7-10 Sec
	xv)	a) Closing Coil Voltage	220 V DC
		b) Permissible Variation in Voltage	85% to 110%
	xvi)	a) Tripping Coil Voltage	220 V DC
		b) Permissible Variation in Voltage	70% to 120%
	xvii)	a) Mechanical Life	20,000
		b) Electrical Life with maintenance (changing arcing Contracts)	20,000
	xviii)	Termination suitable for Aluminium asper IS 13947 Part-II	Yes
	xix)	Insulation Material conforming to GlowWire Test	Yes
	xx)	Mechanical Interlock for Incomer & BusCoupler	Yes via Castel Lock
	xxi)	Rated duration of Short Circuit Current	3 Sec
	xxii)	Maximum Temperature rise aboveAmbient at Rated Current	50^{o}C
	xxiii)	Rated Operating Duty	O – 0.3 Sec – CO – 3 Min – CO
	xxiv)	Rated Short Circuit Breaking Capacity	30 MVA
9.	BUSBAR :		
	i)	Rated	As required.
	ii)	Short circuit withstand current	50KA (rms) for 400KV substation,**40KA** (rms) for 220 & 132KV substation
	iii)	Duration of Short Circuit	3 second
	iv)	Rupturing withstand current	106.56 (peak) KA
	v)	Temp. rise above ambient at ratedcurrent	50^{o}C
	vi)	Made of Aluminium of current density nothigher than	As per requirement
	vii)	Insulation voltage	1.1KV
10.	SWITCHES (SFU / MCCB) :		
	i)	System Voltage	415 V AC ± 10%
	ii)	Insulating Voltage	1.1 KV
	iii)	Rated Imp withstand Voltage of mainCktUimp	8 KV
	iv)	Ambient Temperature	50^{o}C
	v)	Rated Frequency	50 Hz
	vi)	Rated Continuous Current at 50^{o}C	As per Rating
	vii)	Ultimate Short Ckt Breaking Capacity Icu	35 KA
		Service Short Ckt Breaking Capacity Ics	100% of Icu

	viii)	Utilisation Category	A
	ix)	Suitable for Isolation	Yes
	x)	No. of Poles	4 Pole or 2 Pole – as per requirement
	xi)	a) Shunt Release Voltage	220 V DC
		b) Permissible Variation in Voltage	85% to 110%
	xii)	Termination suitable for Aluminium asper IS 13947 Part-II	Yes
	xiii)	Insulation Material conforming to GlowWire Test	Yes
	xiv)	Thermal Over load Settings	Adjustable
	xv)	Short Circuit Setting	Adjustable for 4 Pole and Fixed for 2Pole
11.	FUSE :		
	i)	Type	HRC
	ii)	Rupturing current	Less than breaker rupturing current
	iii)	Maximum rise of temperature at ratedcurrent fuse above ambient	$50^{o}C$
	iv)	Link base	Mode of porcelain equivalent element

N.B. The outgoing feeders are meant for A.C supply to different control panel, protection panel, Battery charger, PLCC equipment, etc and Transformer auxiliary supply, CB/Isolator auxiliary supply,switchyard lighting, water supply, air conditioning system at control room building, fire fighting system, oil filtration and other auxiliary supply related to 400/220/132 KV sub-station.

The successful bidder is to supply AC distribution board to be finalized as per requirement duringdetailed engineering and as per approved drawings, which shall be within the scope of bidder.

27.14 Catalogue of all relays with characteristic curve shall be submitted with tender documents.

27.15 **Sub Vendor List for ACDB**

Sl No.	PRODUCT	MAKE
1	**METERS DIGITALANDANALOGUE** AMMETER,VOLTMETER,	MECO,SECURE,RISHABH, VAISHNO
2	**KWHMETER**	L&T, SECURE, RISHABH
3	**FREQUENCYMETER**	RISHABH, MECO, VAISHNO
4	**FUSE FITTING &FUSELINK**	COPPERBUSHMANN, ABB, SIEMENS, L&T, GE
5	**TRANSDUCERS**VOLTAGETRANSDUCER ,CURRENTTRANSDUCER,FREQUENCY TRANSDUCERETC.	ELSTER, RISHABH, SIEMENS
6	**CONTACTORS**	L&T, SIEMENS, SCHNEIDER, GE, ABB

8	**PROTECTION AND OTHER RELAYS**	ABB,GE,SIEMENS,Schneider
7	**SFU, MCCB,**	GE, ABB, L&T, SIEMENS, LEGRAND, SCHNEIDER
8	**MCB,**	SCHNEIDER,LEGRAND,ABB, SPRECHER &SCHUH(S&S)
9	**CT**	C&S, KAPPA, GILBERT MAXWELL, ABB,PRAGATI, GE, BHEL,SIEMENS
10	PT	C&S, KAPPA, GILBERT MAXWELL, CGL
11	**LTCONTROLSWITCHES**AMMETER, VOLTMETER SELECTOR SWITCHES, BREAKER CONTROL SWITCHES,ROTARY CAM/ROTARYSWITCH	KAYCEE, RECOM, SWITRON, VAISHNO, GE, ABB
12	**ANNUNCIATOR,HOOTER,BUZZER, ELECTRONIC BELL.**	PROTON,MINILEC,ALAN, VAISHNO.,PROCON,PIRI
13	**TERMINAL BLOCK,TERMINAL END PLATE**	ELMEX, CONNECTWELL
14	**SPACE HEATER**	SOFIA,GIRISH(EGO), VIKASELECT., GIRISH, APTCONTROL, KONTACT PYROS, TELELEC, HOTWELL,
15	**THERMOSTAT**	GIRISH(EGO),VIKASELECT., APTCONTROL, KONTACTPYROS
16	**PANELTUBE FIXTURE, CHOKE, STARTER,ILLUMINATION LAMP**	PHILIPS,BAJAJ
17	**3PIN SWITCH SOCKET(INDUSTRIAL/SERVICE)/RECEPTACLE**	ANCHOR, CGL,SCHNEIDER, LEGRAND,ABB
18	**BUS BAR SUPPORTINSULATOR**	RAMANUJ,POWERMAT,VINAYAK,SUNINSULATOR, TECHNO, ESBEECONTROL
19	**PVC/FRLSWIRE**	KEI, POLYCAB, FINOLEX
20	**LUGS**	DOVELLS,COMET,JAIN ELECTRONICS,SJMETAL
21	**HARDWARE MS&SS**	TVS,KUNDAN,AGRWAL FASTENERS,FITRIGHT
22	**POWER PACKS**	ALAN
23	**INDICATING LAMP/LED,FILLAMENT LAMP**	L&T, GE,SIEMENS, SCHNEIDER
24	**PUSHBUTTONS WITH ELEMENTS**	L&T, ABB,SIEMENS
25	**ELECTRONICTIMER**	L&T, GE, ABB, SCHNEIDER, SIEMENS
26	**RUBBERGASKET (NEOPRINE/EPDM)**	MINERVARUBBER&ENGG IND.,HANUIND., JSONPOLYMER, RITTAL, R K PROFILE, ASP MINERVA, RKPROFILE

27	**M.S.CRCA/HRCASHEETS /COILS**	TATA,SAIL,ESSAR
28	**ALUMINIUMBUSBAR**	SUDAL,HINDALCO,JINDAL, BALCO
29	**COPPER BUSBAR**	VIJAY IND., NEW INDIA CUPROTEC, CUBEXTUBING LTD (HYDERABAD)., ALCOBEXJODHPUR(MUMBAI),,MODISONME TAL,CITIZENMETALLOYS(AHMEDABAD), RHJ EXTRUSION(DAMAN)
30	**LIMITSWITCH/DOORLIMIT SWITCH**	KAYCEE,RECOM,SIEMENS, VAISHNO, L&T
31	**ALLUMINIUM SHEET /STAINLESSSTEELSHEET/COILS**	ESSAR,BALCO, HINDALCO, SAIL, TATA
32	**OIL & WINDINGTEMPERATURE INDICATOR**	PRECIMEASURE,PERFECT CONTROL(CHENNAI)
33	**AIR CIRCUITBREAKER(ACB)**	L&T, GE, ABB, SCHNEIDER, SIEMENS
34	**TIMESWITCH**	L&T, GE, ABB, SCHNEIDER, SIEMENS
35	**2POLEAC/DCSWITCH**	GE, SCHNEIDER
36	**LIGHTING TRANSFORMER**	INDCOIL, GUJARATPLUGIN, LOGICSTAT

GUARANTEED TECHNICAL PARTICULARS FOR 400/230 VOLTS A.C. POWER DISTRIBUTION SWITCHBOARDS

(To be filled in and signed by the Bidder)

1	**ACDB GENERAL**	
1.01	Name of Manufacturer	
1.02	Location of the Factory	
1.03	Date of Last Type Test Done	
1.04	Conforming Standard	
1.05	Type & Model of the ACDB as per Manufacturer	
1.06	Dimension of Panel (L x B x H) -mm	
1.07	Total Number of Incoming& OutgoingCompartment	
2	**Bus-Bar Material**	

2.1	Dimension (Width x Thickness) -mm	
2.2	Continuous Current Rating in Amps	
2.3	Current density (Amp/Sq.cm.)	
3	Air Circuit breaker	
3.01	Manufacturer	
3.02	Type & Model as per manufacturer	
3.03	Conforming Standard	
3.04	No of Poles	
3.05	Opening / Closing Time (ms)	
3.06	**Current**	
3.06.1	Rated continuous current carrying capacity inAmps	
3.06.2	Rated SC Current at 415 V (KA rms)	
3.06.3	Making capacity	
3.06.4	Rated SC Breaking Current at 415 V (KA rms)capacity	
3.06.5	Short time ratings for 1 sec.	
3.07	**Voltage**	
3.07.1	Rated Voltage	
3.07.2	Basic Insulation Level	
3.07.3	Closing/Tripping Coil Voltage	
3.08	Maximum temperature rise above ambienttemperature of 50^{o}C	
3.09	CT provided with ACB	
3.09.1	Manufacturer	
3.09.2	Type as per manufacturer	
3.09.3	Number of Core	
3.09.4	Ratio	
3.09.5	VA burden	

3.09.6	Accuracy class	
3.09.7	Type of insulation	
4	Fuse Switch Unit / Switch Disconnctors	
4.01	Manufacturer	
4.02	Type/ Model as per manufacturer with numberof Poles	
4.03	Conforming Standard	
4.04	Voltage	
4.04.1	Rated Operational Volatge without derating	
4.04.2	Insulation Volatge	
4.04.3	Impulse Withstand Voltage	
4.05	Current	
4.05.1	Operational Current	
4.05.2	Conventional enclosed Thermal Current ratingat 45 ^{0} C	
4.05.3	AC 23 A Utilisation Category Rating at 415 V (A)	
4.05.4	DC 23 A Utilisation Category Rating at 220 V DC(A)	
4.05.5	Rated AC Making Capacity at 0.35 pf	
4.05.6	Rated AC Breaking Capacity at 0.35 pf	
4.05.7	Rated DC Making Capacity / DC BreakingCapacity at 220 V, L/R 15 ms	
4.05.8	Rated Conditional Fused SC Current (KArms)	
4.05.9	Back-up Fuse rating	
4.05.10	Maximum Cut Off Current permitted (Kap)	
4.05.11	Rated AC Capacitor Power (KVAr) at 415 V AC	
4.05.12	Mechanical Endurance Cycle (number)	
4.05.13	Electrical Endurance Cycle at 0.65 pf (number)	
4.05.14	Auxilary Contact Thermal rating (A)	

5	A.C. Meters / Energy Meters (Details for Ammeters, Voltmeters, Energy-meters shall befurnished separately)	
5.01	Manufacturer	
5.02	Type	
5.03	Range	
5.04	Accuracy	
5.05	Conforming Standard	

CHAPTER – 28: SPECIFICATION FOR DCDB

28.1 SCOPE:

a) This specification covers design, manufacture, assembly, testing, supply, and delivery at site of DC switchboard. This also includes design, supply, commissioning, laying and termination of D.C. supply cables of 1.1KV grade XLPE insulated stranded Copper cables of different sizes as per requirement for distribution of D.C. supply at different points of switchyard, control room building, Fire-fighting pump house etc. for various purpose for 400/220/132/33KV sub-station.

DC PANEL

Two numbers of D.C. Panel for distribution of D.C. supply associated with DC Supply of 400, 220,132 and 33kV System at different points in Control Room, Switch Yard and other locations as per need. The DC Panel shall have Two Incomer connected with Battery Charger -1 & BatteryCharger -2 wrt to Battery set - 1 & Battery set - 2. The DC Panel shall have one BusCoupler with proper Interlocking for independent operation of each DC System.

28.2 STANDARDS :

The equipment covered by this specification shall unless otherwise stated, be designed, constructed and tested in accordance with the applicable sections of the latest Indian Standard Specification and Indian Electricity Rules and as per this technical specification. The degree of protection shall not be less than IP-54. However, Bus bar chamber having a degree of protection of IP:42 as per IS:2147 where continuous bas bar rating exceeds 1000A.

28.3 DEVIATION :

Normally the offer should be as per Technical Specification without any deviation, **In case of any deviation taken against technical specification same are to be submitted in a separate deviation sheet for review of AEGCL.**

28.4 MODIFICATION :

If any modification felt necessary to improve performance, efficiency and utility of equipment, the same must be mentioned in the 'Modification schedule' with reasons duly supported by documentary evidences and advantages. Such modifications suggested may or may not be accepted, but the same must be submitted along with Pre-Bid Queries. The modifications not mentioned in Schedule will not be considered.

28.5 GENERAL SPECIFICATION OF D.C. SWITCH BOARD :

220 (+/- 10%) volt D.C. supply shall be made available from the station storage

battery banks associated with battery charger. In case of existing sub-station, sub-station wise DC voltage shall be intimated to the successful bidder. The charger and battery shall be connected to the load bus of D.C. switchboard through separate 2-pole MCCB of suitable rating. There shall be interlocking arrangement through pad locks and keys so that one breaker can be closed at a time.

The D.C. switch boards shall be of multi-cubicle on multi box factory build air insulated type, fully enclosed with doors for access to the interior, 3.00 mm. thick steel sheet shall be used for the fabrication of the panels. Steel used for manufacturing shall be of reputed MAKE. Boards shall be easily extendible on both side, by addition of the vertical sections after removing the end covers. Dimension shall not be more than 1800 mm. high with channel base and 800 mm depth (or as per requirement) measured from the rear to front face. The working height of the switch board shall be minimum 450 mm. to maximum 1650 mm. The back cover of the switch board shall be provided with hinged door with locking arrangement. Length of the panel shall be determined as per no of circuits to be accommodated. All boards shall be divided into distinct vertical sections each comprising of -

(i) A completely enclosed bus bar compartment for running horizontal and vertical Copper bus bar. Bus bar chamber shall be completely enclosed with metallic portions. Bolted covers shall be provided for access to horizontal and vertical bus bars and all joints for repair and maintenance, which shall be feasible without disturbing feeder compartment. Proper ventilation arrangement shall have to be arranged and that shall be decided by the purchaser at the time of approval. Bus bar rating shall be as per requirement with additional 30% margin.

(ii) Completely enclosed switchgear compartments one for each circuit for housing incoming MCCB and outgoing MCCB.

(iii) A compartment for power and control cables. Door of compartment shall be hinged. Cable compartment shall have no communication with bus bar chamber.

(iv) A compartment for relays and other control devices associated with Incoming MCCB.

28.6 DESIGN:

i. The D.C. switch boards shall be designed to facilitate cable entry from the bottom through entry holes of removable plates provided at the bottom of the cubicle. All the accessories required for termination of cable in the DCDB such as screwed brass cable gland, terminal block etc. shall be within the scope of supply, Gland shall project above the gland plate. Terminating cable shall be armoured and armoured rods shall be connected to earth bus. After isolation of power and control circuit connections it shall be possible to safely carryoutmaintenance in a compartment with the bus bar and adjacent circuit live. Necessary shrouding arrangement shall be provided for this purpose over the cable terminations located in cable alley.

ii. In case of providing two incomer MCCB compartment in the same vertical section, insulating barriers and shroud shall be provided in the rear cable compartment in order to avoid accidental touch with live part of one circuit when working with the other circuit.

iii. The connections from bus bars to main switch shall be fully insulated/shrouded and securely bolted. The partition between the feeder compartment and cable alley may be non-metallic and shall allow cable cores with lugs to be easily inserted in the feeder compartment for termination.

iv. Necessary and safe earthing arrangement with supply of all accessories required for safe earthing shall be within the scope of supply.

v. **A copper earthing bus bar** shall be provided at the bottom of each panel and shall extend through out the length of switchboard. It shall be welded/bolted to the frame work of each panel and breaker. Earthing contact bar vertical bus shall be providein each vertical section which shall in turn be bolted/welded to main horizontal ground bus.

vi. The earth bus shall have sufficient cross-section to carry momentary short circuit and short line fault currents to earth bus without exceeding the allowable temperature rise.

vii. The horizontal earth bus shall be projected out to the switchboard ends and shall have predrilled holes for bolted connection between this bus to sub-station earthing conductor. A joint spaced and taps to earth bus shall be made through at least two bolts.

viii. All non-current metal works of the switchboard shall be effectively connected to the earthbus.

ix. The switchboard shall be dust and vermin proof and suitable for use in tropical climate. All ventilating louvers and holes shall be covered with fine non-ferrous wire mesh from inside. A suitable rust resisting primer paint shall be applied on the panel after the same is polished and the primer shall be evenly sprayed. The colour of the exterior of the panel shall be of same colour as that of the main control and relay panel. The colour of the interior panel should be as to provide a colour contrasting background for the wiring inside the cubicle.

x. The switchboards shall be mounted on channel and shall be complete with channel bottom plates, grouting bolts, earthing bolts, washers, cable glands etc. Fabrication of the channels shall be robust.

xi. All the MCCB's shall be of best quality and easy in operation.

xii. The number of outgoing feeders shall be controlled by suitably rated MCCB. Necessary arrangement shall be kept especially for emergency sub-station control building lighting particularly in Control room, ACDB room, Battery room, Fire fighting pump house, Corridor, Lobby, Stairs and oter emergency loads etc. in case of failure of AC main supply. Provision for audio visual indication with lamp and bell with facility for manual cancellation & resetting of alarm for failure of D.C. supply to the load bus or blowing of any fuse of D.C. circuit shall be made. Switchboard shall be installed in the DCDB room of control room building of 400/220/132/33KV sub-station. In case of tripping of any outgoing feeder MCCB, visual and audible alarm arrangement shall be provided in the DC Board as well as in the control room. Necessary arrangement shall also be provided for acceptance and resetting of the audible alarm. In case of tripping of Incoming feeder breaker, arrangement of both audible and visual annunciation shall be made at DC Board and control room. Acceptance and resetting arrangement is also to be provided. Visual indication of the failure of D.C. voltage at the load bus or blowing of any fuse can only be cancelled when the supply at bus will be restored or the fuse is replaced.

xiii. Adopter panels and dummy panels required to meet the various bus bar arrangements and layouts required shall be included in bidders' scope.

xiv. The temperature rise of horizontal and vertical bus bars when carrying rated current along its full run shall not exceed 55ºC with Silver plated joints and 40ºC with all other type of joints over an outside ambient temperature of 50ºC.

xv. All identical circuit breakers and module chassis of same test size shall be fully interchangeable without doing any modification work.

xvi. MCCB & MCB shall be from one of the following manufacturer's complying with technicalspecification & relevant IS & IEC

a) M/s Siemens
b) M/s L & T
c) M/s ABB
d) M/s Schneider

28.7 INTERNAL WIRING AND TERMINAL BLOCK :

28.7.1 All connection terminals shall be brought in the terminal block which shall be fixed in such a position as may be readily accessible.

28.7.2 All switchboards shall be supplied completely wired internally upto the terminal blocks.

28.7.3 All inter cubicle and inter panel wiring and connections between panels of same switchboard including all bus wiring for A.C. and D.C. supply shall be provided by the contractor.

28.7.4 All internal wiring shall be carried out with XLPE insulated stranded copper conductor 2.5 sq. mm. However for annunciation scheme wiring may be drawn with 1.5 sq. mm XLPE insulated stranded copper conductor.

28.7.5 All wiring shall be properly supported, neatly bunched, and readily accessible and securely connected to equipment terminals and terminal blocks.

28.7.6 There shall be ferrule marking at both ends of the connections. Red ferrule with positive marking shall be used for the positive terminals and white ferrule with negative marking for negative terminal for D.C. wiring.

28.7.7 Each wire shall be continuous and there shall not be any joint within itself. Wiring for meter, relays, instruments and MCCB etc. used in the switchboard shall be brought to the terminal block.

28.7.8 Terminal blocks shall be of 1100V grade ‘Elmex’ / ‘Connectwell’ make and have continuous rating to carry the maximum expected current on the terminals as well as short circuit current for specified duration. The terminal blocks shall be fully enclosed with removable covers of transparent, non-deteriorating type plastic material. Insulating barrier shall be provided between the terminals. The terminal blocks shall have locking arrangement to prevent its escape from the rails.

28.7.9 All terminal blocks shall be normally suitable for terminating on each side two nos. of 2.5 sq. mm. size stranded copper conductor.

28.7.10 If required TBs of other sizes shall also be provided.

28.7.11 All terminals shall be numbered for identification and grouped according to the function. Engraved white on black **anodized aluminum** labels shall be provided on the terminal blocks.

28.7.12 Terminal blocks shall be arranged with at least 200 mm clearance between two sets of terminal block. The minimum clearance between the first row of terminal block and the associated cable gland plate shall be 250 mm.

28.7.13 Interlocks shall be designed for both the incomer breakers and bus coupler breaker. Interock logics shall be decided during detailed engineering.

28.8 NAMEPLATES AND LABELS :

D.C. distribution boards shall be provided with prominent, engraved identification plates. The module identification plate shall clearly give the feeder number and feeder designation. For single front switchboards, similar panel and board identification labels shall be provided at the rear also.

28.9 EQUIPMENT AND OTHER TECHNICAL INFORMATION FOR D.C. SWITCHBOARD :

28.9.1 One set of copper bus bar of adequate continuous rating as well as specified short circuit rating of specific duration, having continuous current density shall be provided.

28.9.2 Aux. Relay and contactor for alarm as well as visual indication against tripping of incoming MCCB as well as outgoing feeder MCCB shall be provided. However, indication will not go off till the restoration of failure.

28.9.3 ‘ON’, ‘OFF’ and ‘TRIP’ indicating lamps for both the incoming MCCB along with required number of push button shall be within the scope of supply.

28.9.4 Digital D.C. voltmeters having a scale range of 0-300 V.D.C. flush mounted, type having accuracy. +/- 1% of full scale, shall be provided as per requirement. The meters shall conform to the appropriate IS specification.

28.9.5 Digital D.C. ammeters, flush mounted, having range of 0-300 Amps. and accuracy +/- 1% of full scale, shall be provided for measurement of load current flowing to the D.C. switchboard. Rating of ammeter hall change if the load requirement is changed. Changed rating meters shall be under the scope of the successful bidder.

28.9.6 The ampere rating of MCCB for feeder protection shall be as per requirement of the feeder current but shall not be less than 32 Amps.

28.9.7 Doors at the back of the panel shall be provided for inspection with door switch for illumination of the lamp to be provided inside the panel with separate switch fuse unit for controlling the lamp.

28.9.8 All the indicating lamps shall be of panel mounting cluster LED type. The lamps shall have suitable size plates marked with its function, wherever necessary. Lamps shall have translucent lamp covers of ‘RED’, ‘GREEN’ & ‘WHITE’ colour for indicating , ‘ON’, ‘OFF’ and ‘AUTO-TRIP’ indication of incoming MCCB’s. One no. Indicating lamp is to be provided for tripping of outgoing feeder & DC supervision.

28.9.9 Space heater shall be provided for preventing harmful moisture condensation in all the D.C. Boards. The space heaters shall be suitable for continuous operation of 240V AC, 50HZ single phase supply and shall be automatically controlled by thermostats. Necessary isolating switches and HRC fuses shall be provided.

28.9.10 All the D.C. and A.C. HRC fuses, D.C. Aux. Relays, isolating copper links, D.C. emergency fuse,

28.9.11 D.C. emergency & A.C. emergency contactor, A.C. bell, indicating lamp for indicating D.C. fail of main bus, D.C. contactor etc. shall be within the scope of supply of the contractor. Three nos. Push Button for testing annunciation scheme, resetting annunciation scheme and accept of fault and bell cancellation shall be provided.

28.9.12 Moulded case circuit breaker for both incomer circuit shall be of suitable Amp. rating (as per requirement) and double pole type. Each MCCB shall be provided with trip coil. MCCB shall be capable of safely breaking the fault current of the associated incoming feeder.

28.9.13 All the MCCB shall be flush mounted on D.C. Distribution boards.

28.9.14 MCCB’s shall be provided with thermo-magnetic type release for over current and short circuit protection.

28.9.15 The setting range of thermal release and breaking capacity of MCCB’s are to be specified and shall conform to circuit requirement.

28.9.16 MCCB shall have Mechanical Anti-reclosing and facilities for over load and short circuit setting adjustment. MCCB knob shall indicate the true position of the equipment. MCCB’s shall conform to relevant Indian Standard.

28.9.17 Interlocks shall be provided such that it is possible to open the cubicle door only when the MCCB is in 'OFF' position and to close the MCCB when the door is closed.

28.10 GUARANTEE :

Electrical characteristics shall be guaranteed by the contractor. In case of failure of materials to meet the guarantee, AEGCL shall have right to reject the material. Guaranteed Technical particulars are to be submitted by successful bidder during detailed engineering along with submitted drawings/documents. However, format for submission of GTP shall be handed over to intending bidders at the time of sale of tender documents.

28.11 PACKING AND DESPATCH :

All equipment shall have to be dispatched suitably and securely packed in wooden crates,suitable for handling during transit by rail and / or road.

28.12 CONTRACT DRAWINGS AND CATALOGUE :

After placement of Letter of Award four (4) copies of following drawing, G.T.P and literature shallbe submitted for approval.

(i) Single line diagram for each type of switchboard.

(ii) Dimensional drawing showing clearly the location of meter switches, MCCB etc. in the D.C. switchboard arrangement in plan and elevation with foundation details.

(iii) Wiring diagram of D.C. switchboard showing the interconnection between terminals of various equipment and devices on and within the panel including approved schematic drawings.

(iv) Take off terminal connection arrangement.

(v) Catalogue of D.C. switchboard equipment.

28.13 TEST AT MANUFACTURER'S WORKS AND TEST CERTIFICATES :

Acceptance and routine test at manufacturers' works shall be carried out on each A.C. Board as per stipulation of relevant Indian Standard. The following tests on each switchboard shall be carried out and two copies of the test certificates to be submitted.

(i) Checking of wiring and continuity of the circuit.

(ii) Power frequency voltage test of 3KV for one minute between wiring and earth terminal.

(iii) Insulation resistance value of all equipment. Connected in switchboard and function of the same.

All the acceptance and routine tests shall be carried out in presence of representative of AEGCL. All tests and inspection shall be made at the place of manufacturer. The manufacturer shall provide reasonable testing and inspection facilities and co-operation without any charge to satisfy the representative that the material is being supplied is in accordance with this specification. The proto of DCDB shall be inspected & checked by Ordering Authority or his representative for approval before commencement of supply. The entire cost of acceptance and routine tests that are to be carried out as per relevant IS shall be treated as included in quoted price of DCDB.

QAP: The bidder shall submit the standard Quality Assurance Plan mentioning all the routine test, FAT, site test etc.

28.14 TESTS REPORTS AND TYPE TESTS :

Type test reports of identical equipment shall be submitted in three copies.
All the Type Tests shall be carried out from laboratories which are accredited by the National Board of Testing and Calibration Laboratories (NABL) of Government of India such as CPRI/ERDA, to prove that the MCBs & other components used in DCDB meet requirements of the specification.

SPECIFIC TECHNICAL PARTICULARS OF D.C. DISTRIBUTION BOARDS

SNO	DESCRIPTION	TECHNICAL PARTICULARS
1.	Dimensions : a) Height of complete panel (mm.) b) Working height (mm.) c) Width (mm.) d) Depth	1800 (max.) 450(min.)to 1650(max.) As per requirement. 800 mm (max.) or as per manufacturers type tested design
2.	Sheet steel thickness of panel (mm.)	3 (min.)
3.	Grade of insulation Level of equipments and wiring(KV)	1.1
4.	Annunciation for blowing of fuse or tripping of breaker	Alarm and visual indication
5.	Ammeter range	0 to **300** (or as per requirement of the load)
6.	Voltmeter range	0 to 300
7.	Accuracy class of Ammeter & Voltmeter	1% of full scale deflection
8.	Current density of Aluminium for Busbar (A/sq.mm.)	As per bus bar sizing
9.	Wiring for annunciation scheme shall be done with copper of cross-section area (sq.mm.)	1.5 (Stranded)
10.	MCCB i) System Voltage ii) Insulating Voltage iii) Rated Imp withstand Voltage of main Ckt Uimp iv) Ambient Temperature v) Rated Continuous Current at 50^{o}C vi) Ultimate Short Ckt Breaking Capacity Icu vii) Service Short Ckt Breaking Capacity Ics viii) Utilisation Category ix) Suitable for Isolation x) No. of Poles xi) Shunt Release Voltage xii) Permissible Variation in Voltage xiii) Termination suitable for Aluminium as per IS13947 Part-II xiv) Insulation Material conforming to Glow Wire Test xv) Thermal Over load Settings xvi) Short Circuit Setting	220 V DC 690 V 8 KV 50^{o}C As per Rating 10 KA (DC Breaking) for < 100 A &30 KA for > 100 A 100% of IcuA Yes 4 Pole or 2 Pole – as perrequirement 220 V DC 85% to 110% Yes Yes Adjustable Adjustable for 4 Pole and Fixed for2 Pole

Note: The contractor is to supply DC switch board as per requirement after detailed engineering. Emergency lamp circuit in control room shall be automatically put into service through contactors when the AC supply will fail. **Catalogue of all relays with characteristic curve shall be submitted with tender documents**.

28.15 Sub Vendor List FOR DCDB:

Sl No.	PRODUCT	MAKE
1	**METERS DIGITALANDANALOGUE** AMMETER,VOLTMETER,	MECO,SECURE,RISHABH, VAISHNO
2	**KWHMETER**	L&T, SECURE, RISHABH
3	**FREQUENCYMETER**	RISHABH, MECO, VAISHNO
4	**FUSE FITTING &FUSELINK**	COPPERBUSHMANN, ABB, SIEMENS, L&T, GE
5	**TRANSDUCERS**VOLTAGET RANSDUCER,CURRENTTR ANSDUCER,FREQUENCY TRANSDUCERETC.	ELSTER, RISHABH, SIEMENS
6	**CONTACTORS**	L&T, SIEMENS, SCHNEIDER,GE, ABB
8	**PROTECTIONANDOTHERRELAYS**	ABB,GE,SIEMENS,Schneider
7	**SFU, MCCB,**	GE, ABB, L&T, SIEMENS,LEGRAND, SCHNEIDER
8	**MCB,**	SCHNEIDER,LEGRAND,ABB, SPRECHER &SCHUH(S&S)
9	**CT**	C&S, KAPPA, GILBERT MAXWELL, ABB,PRAGATI, GE, BHEL, SIEMENS
10	PT	C&S, KAPPA, GILBERTMAXWELL, CGL
11	**LTCONTROLSWITCHES**AMMETER, VOLTMETERSELECTOR SWITCHES,BREAKER	KAYCEE, RECOM, SWITRON, VAISHNO, GE, ABB
	CONTROLSWITCHES,ROTARYCAM / ROTARYSWITCH	
12	**ANNUNCIATOR,HOOTER,BUZZER, ELECTRONICBELL.**	PROTON,MINILEC,ALAN,VAISHNO.,PROCON,PIRI
13	**TERMINAL BLOCK,TERMINALENDPLATE**	ELMEX, CONNECTWELL
14	**SPACEHEATER**	SOFIA,GIRISH(EGO), VIKASELECT., GIRISH,APTCONTROL, KONTACT PYROS, TELELEC,HOTWELL,
15	**THERMOSTAT**	GIRISH(EGO),VIKASELECT.,APTCONTROL,KONTACTPYRO S
16	**PANELTUBEFIXTURE, CHOKE, STARTER,ILLUMINATINLAMP**	PHILIPS,BAJAJ

17	**3PIN SWITCH SOCKET(INDUSTRIAL/SERVICE)/RECEPTACLE**	ANCHOR, CGL,SCHNEIDER, LEGRAND,ABB
18	**BUS BAR SUPPORTINSULATOR**	RAMANUJ,POWERMAT,VINAYAK,SUNINSULATOR, TECHNO , ESBEECONTROL
19	**PVC/FRLSWIRE**	KEI, POLYCAB, FINOLEX
20	**LUGS**	DOVELLS,COMET,JAINELECTRONICS,SJMETAL
21	**HARDWAREMS&SS**	TVS,KUNDAN,AGRWALFASTENERS,FITRIGHT
22	**POWERPACKS**	ALAN
23	**INDICATINGLAMP/LED,FILLAMENTLAMP**	L&T, GE,SIEMENS,SCHNEIDER
24	**PUSHBUTTONSWITHELEMENTS**	L&T, ABB,SIEMENS
25	**ELECTRONICTIMER**	L&T, GE, ABB, SCHNEIDER, SIEMENS
26	**RUBBERGASKET (NEOPRINE/EPDM)**	MINERVARUBBER&ENGGIND.,HANUIND.,JSONPOLYMER, RITTAL, R K PROFILE, ASP MINERVA, RKPROFILE
27	**M.S.CRCA/HRCASHEETS /COILS**	TATA,SAIL,ESSAR
28	**ALUMINIUMBUSBAR**	SUDAL,HINDALCO,JINDAL, BALCO
29	**COPPERBUSBAR**	VIJAY IND., NEW INDIA CUPROTEC, CUBEXTUBING LTD (HYDERABAD)., ALCOBEXJODHPUR(MUMBAI),,MODISONMETAL, CITIZENMETALLOYS(AHMEDABAD),RHJ EXTRUSION(DAMAN)
30	**LIMITSWITCH/DOORLIMIT SWITCH**	KAYCEE,RECOM,SIEMENS, VAISHNO, L&T
31	**ALLUMINIUM SHEET /STAINLESSSTEELSHEET/COILS**	ESSAR,BALCO, HINDALCO, SAIL, TATA
32	**OIL & WINDINGTEMPERATURE INDICATOR**	PRECIMEASURE,PERFECTCONTROL(CHENNAI)
33	**AIR CIRCUITBREAKER(ACB)**	L&T, GE, ABB, SCHNEIDER, SIEMENS
34	**TIMESWITCH**	L&T, GE, ABB, SCHNEIDER, SIEMENS
35	**2POLEAC/DCSWITCH**	GE, SCHNEIDER
36	**LIGHTING TRANSFORMER**	INDCOIL, GUJARATPLUGIN,LOGICSTAT

CHAPTER 29: SPECIFICATIONS FOR COMMUNICATION EQUIPMENT FOR ESTABLISHMENT OF FIBRE OPTIC COMMUNICATION SYSTEM

29.0 Introduction, General Information and General Requirement

This Chapter describes the technical specifications for Communication Equipment for Establishment of Fibre Optic Communication System under the contract. This specification describes the functional and performance requirements of the system.

29.1 Scope and General Requirements

The broad scope of the procurement of this part include the survey, planning, co-ordination with other suppliers' equipment, design, engineering, supply, transportation, insurance, delivery at site, unloading, handling, storage, installation, termination, testing, training, and demonstration for acceptance, commissioning and documentation for

(i) SDH Equipment along with suitable optical line interfaces & tributary cards.
(ii) Integration with existing NMS at SLDC.
(iii) All cabling, wiring, Digital Distribution Frame patch facilities and interconnections to the supplied equipment at the defined interfaces.
(iv) System integration of the supplied subsystems and also integration with existing communication equipment such as SDH
(v) Integration of supplied system with the User equipment such as RTUs, SCADA system SAS etc.
(vi) Maintenance of the supplied system
(vii) Integration/Interfacing with PLCC/DPC

All other associated works/items described in the technical specifications for a viable and fully functional communication network.

The network shall comprise multi input and multi output fibre optic equipment complete for speech communication in dialling mode and or through express telephone, data communication, fibre optic based power system protection, suitable for multi point to multi point fibre optic network. The terminal optical communication equipment shall be installed in the Sub Stations to be constructed under this Package (only for 400kV Voltage Level.

The responsibility of connecting the optical terminal equipments with the FODP of the respective substation shall rest with this contract. Also, the connection of OLTE with FODP is within the scope of this contract..

29.2 General Requirements

29.2.1 It should be noted that preliminary design information and bill of quantity (BOQ) specified in this specifications are indicative only. The Contractor shall verify the design data during the site surveys & detail engineering and finalise the BOQ as required for ultimate design & system performance.

29.2.2 The Tenderer'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.

29.2.3 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 Tenderers shall identify and include all such additional items and services in their proposal.

29.2.4 All telecom equipment provided shall be designed to interface with existing telecom equipment and shall be capable of supporting all present requirements and spare capacity requirement identified in this specification.

29.2.5 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.

29.2.6 The Tenderer is supposed to make necessary survey for integration of the SDH Equipment with the existing NMS at SLDC, Kahilipara. For this if any traffic routing to SLDC is required through other Utilities; AEGCL will arrange the same. However, during interfacing with the existing telecom equipment if any hardware/software is required (at SLDC or Remote end), the Bidder has to offer the same with no cost implication to AEGCL.

29.2.7 The Tenderers 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 tenderer (Contractor) is required to visit all sites. The site visits after contract award shall include all necessary surveys to allow the contractor to perform the design and implementation functions. The Contractor shall inform their site survey schedule to the Employer well in advance. The site survey schedule shall be finalised in consultation with the Employer. The Employer may be associated with the Contractor during their site survey activities. After the site survey, the Contractor shall submit to the Employer a survey report on each link and site. This report shall include at least the following items:

(a) Proposed layout of Equipment in the existing rooms and buildings.
(b) Proposed routing of power, earthing, signal cables and patch cords etc.
(c) Confirmation of adequacy of Space and AC/DC Power supply requirements
(d) Proposals for new rooms/buildings if required
(e) Identification of facility modifications if required
(f) Identify all additional items required for integration for each site/location.

29.2.8 Synchronization of the Communication Network

The Contractor shall be responsible for synchronization of new communication equipment with existing network utilizing the existing GPS clock. The Contractor shall make an assessment of additional clock requirement for synchronization of the communication equipment.

29.3 General Responsibilities and Obligations

This section describes the general responsibilities and obligations of the Contractor and the Employer.

29.3.1 Responsibilities for the Implementation Plan

The Tenderer's technical proposal shall include a project implementation plan and schedule that is consistent with the implementation plan detailed in this specification. The implementation plan shall be modelled such that it provides fibre optic cabling system support for the activation of this Project. The Implementation plan shall include the activities of both the Contractor and the Employer, showing all key milestones and clearly identifying the nature of all information and project support expected from the

Employer. The Employer and Contractor shall finalise the detailed Implementation plan following award of the contract.

29.3.2 Contractor's Responsibilities and Obligations

The Contractor shall be responsible for all cables and wiring associated with the equipment provided, both inside and outside buildings in accordance with technical specifications. The Contractor shall also be responsible for determining the adequacy of the local power source for the equipment and for wiring to it, with adequate circuit protective breakers. In addition, the Contractor shall be responsible for shielding equipment and cabling to eliminate potential interference to or from the equipment, and for earthing all cabinets and shields.

Contractor's obligations include, but are not limited to, the following:

(1) Site visits, and surveys, necessary to identify and provide all equipment needed to implementation the network.
(2) Equipment Engineering and design specific to each location including review of, and conformance with local environmental and earthing considerations.
(3) Overall integration of communication equipments/subsystem procured in present with existing User equipments such as SDH, RTUs, SCADA, SAS system with SLDC, Kahilipara etc.
(4) All cabling, wiring including supply, laying and termination etc of the cables, and distribution frame at wideband nodes required for full interconnectivity and proper operation of the telecommunications network including equipment supplied under this package and the connectivity and interfacing of user equipment.
(5) Installation and integration of network management software, hardware and firmware.

(6) Project management, project scheduling, including periodic project reports documenting progress, review meeting during the contract period.
(7) Engineering and technical assistance during the contract and warranty period.
(8) Implement all minor civil works and identify any major civil works i.e. expansion or construction of rooms, trenches necessary for installation of proposed equipment and provide the details of such work to the Employer.
(9) Factory and site testing of all hardware, software, and firmware provided.
(10) Provide documented evidence of satisfactory Type Test performance to the Employer and if required by The Employer, conduct type test.
(11) Provide a Quality Assurance Plan, ensuring the Employer access to the manufacturing process.
(12) Training of the Employer personnel.
(13) Hardware, software, and firmware maintenance, debugging, and support of the equipment through final acceptance, and maintenance on all new equipment through out the warranty period.
(14) Availability of service, spare and expansion parts for the supplied items for the designed life of the equipment or seven (7) years after the declaration of withdrawal of equipment from production, whichever is earlier. However, the termination of production shall not occur prior to Operational Acceptance of the system by the Employer.

Detailed descriptions of the Contractor's obligations, in relation to individual items and services offered, are delineated in other sections of this specification.

29.3.3 The Employer Responsibilities and Obligations

The Employer will provide the following items and services as part of this Project:

(1) Overall project management of the project

(2) Review and approval of the Contractor's designs, drawings, and recommendations.

(3) Communication network configuration data, including:
   - (a) Channel assignments for voice and data
   - (b) Interconnection drawings for existing equipment

(4) Review and approval of test procedures.

(5) Participation in and approval of "Type", factory and site acceptance tests where testing is required.

(6) Review and approval of training plans.

(7) Providing support and access to facilities at the sites.

(8) Implement the major civil works such as expansions or construction of rooms, trenches etc. as required for the equipment to be provided by the Contractor.

(9) Coordination of the Contractor's activities with the Employer's and constituents' concerned departments.

(10) Provide to the extent possible drawings for existing sites and facilities for which equipment installations are planned.

(11) Approval of the key personnel for the project

29.4.0 Applicable Standards

The applicable standards are mentioned in the respective technical section. The offered equipment shall conform to the standards mentioned in the specification except to the extent modified by this specification. In case of any discrepancy between the description given in the specification and the standards, the provisions of the technical specification shall be followed. The parameters not specifically mentioned in this specification shall conform to the standard mentioned in this specification.

Specifications and codes shall be the latest version, inclusive of revisions, which are in force at the date of the contract award. Where new specifications, codes, and revisions are issued during the period of the contract, the Contractor shall attempt to comply with such, provided that no additional expenses are charged to the Employer without Employer's written consent.

In the event the Contractor offers to supply material and/or equipment in compliance to any standard other than Standards listed herein, the Contractor shall include with their proposal, full salient characteristics of the new standard for comparison.

In case values indicated for certain parameters in the specifications are more stringent than those specified by the standards, the specification shall override the standards.

29.5.0 Network Configuration and Equipment Characteristics

29.5.1 Introduction

This section describes the Fibre Optic Communication network configuration and the equipment characteristics for communication system to be installed under the project. The sub-systems addressed within this section are:

(1) Fibre Optic Transmission System (FOTS)
(2) Craft Terminal based Network Management System (NMS)
(3) DDF and Cabling

The requirements described herein are applicable to and in support of network requirements.

29.5.2 The security related requirements of the equipment shall be as per DOT (Department of Telecommunication)/ MEITY (Ministry of Electronics and Information Technology) guidelines and all similar security requirements as amended by DoT on time to time basis shall be followed/complied by the vendor at no additional cost to employer till the implementation of the project..

29.5.3 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.

29.5.4 The contractor shall ensure that the supplied equipment have been tested as per relevant contemporary Indian or International Security Standards e.g. IT and IT related elements against ISO/IEC 15408 standards, for Information Security Management System against ISO 27000 series Standards, Telecom and Telecom related elements against 3GPP security standards, 3GPP2 security standards etc. from any international agency/ labs of the standards e.g. Common Criteria Labs in case of ISO/IEC 15408 standards until 31st March 2013. From 1st April, 2013, the certification shall be done from authorized and certified agency/lab in India.

29.5.5 The Contractor shall also ensure that the equipment supplied has all the contemporary security related features and features related to communication security as prescribed under relevant security standards. A list of features, equipments, software etc. Supplied and implemented in the project shall be given for use by the Employer.

29.5.6 The contractor shall get the Employer’s equipment audited from security point of view once a year from a network audit and certification agency as identified by DoT. The audit of the equipment shall be carried once in a financial year till the maintenance service contract in the tender.

29.5.7 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 DoT and any other Government department.

29.6.0 General Network Characteristics

29.6.1 Description

The fibre optic network shall be based on the Synchronous Digital Hierarchy (SDH). The network shall consist of overhead fibre optic links with a minimum bit rate of

Synchronous Transport Module-STM-16 (STM-16). The Contractor can propose a system based on higher bit rate systems, if requir ed, so as to meet the link budget requirements or any other specification requirement. The detailed BOQ is described in appendices. The fibre optic network shall also be able to in tegrate with existing STM-1 network.

29.6.2 Functional Requirement

The primary function of the communication network is to provide a highly reliable voice and data communication system for grid operation in support of the SCADA/EMS/RTUs/SAS. The communications support requirement for SCADA/EMS/RTUs/SAS system is for low & high speed data, express voice circuits and administrative voice circuits as defined in appendices. A brief summary of the communication system requirements is as follows:

(a) High speed E1 channel support

(b) 64kbps & nx64kbps data channel support

(c) Low speed (300-1200 bps) data channel support

(d) Voice (2 wire, 4 wire) channel support

(e) Network Management channels either through (Data Communication Channel(DCC) or through data channel as may be suitable as per site requirement.

(f) The connectivity envisaged for RTUs and SAS with Control Centre (SLDC, Kahilipara) over TCP-IP is Wide Area Network on TCP-IP using IEC 60870-5-104 and IEC 60870-5-101 protocol.

(g) Tele-protection interface for simultaneous transmission and reception of trip (tele-protection) signal from/to one station to/from another two three or more stations. Tele-protections unit should be capable of communicating with remote end tele-protections directly or through fibre with 64kbps or E1 as back up path through fibre optic equipment.

29.6.3 General Systems Requirements

Required characteristics are defined and specified herein at the system level, subsystem level, and equipment level.

29.6.3.1 System Synchronization

The Contractor shall synchronize the existing equipment and all the new equipment under the contract using existing Master clock. The Contractor shall provide the additional clocks as required under the set of clock indicated in BOQ. In addition to GPS input reference, the synchronization clock must have provision to take INPUT reference coming from other clock. The contractor shall submit the synchronisation plan as per standard ITU-T G.811. All sync equipments proposed under this contract should meet ITU-T G.811 criterion. The holdover quality of slave clock, if any, shall meet ITU-T G.812 standard requirements.

The Contractor shall provide system wide synchronization fully distributed throughout the telecom network and connected to all equipments new & existing. The Contractor shall submit the synchronization plan for the entire network meeting the requirement of

ITU-T G.803. The synchronization plan shall clearly indicate the requirement of additional clocks with full justification.

The system equipment requiring "clock" shall be connected to the master clock using external clocking. For this purpose, appropriate interface(s) in the transmission & termination equipment being supplied and all other associated hardware shall be provided by the Contractor.

29.6.3.2 System Maintainability

To facilitate performance trending, efficient diagnosis and corrective resolution, the system shall permit in-service diagnostic testing to be executed both locally and from remote locations, manually and/or initiated under NMS control with graphical user interface. Such testing shall not affect the functional operation of the system.

29.6.3.3 System Upgradeability and Expandability

Equipment supplied shall be sized (though not necessarily equipped) to support system/ subsystem expansion to full capacity as provided by specified aggregate transmission rates. Equipment units provisioned for equipped subunits shall be terminated at appropriate patching facilities or termination blocks. Power supplies and NMS shall be sized for maximum equipped system capacity.

29.6.3.4 Equipment Availability

The calculated availability of each fibre optic link (E1 to E1) shall be at least 99.999%. The average per link subscriber to subscriber availability shall be at least 99.97%. The per link subscriber to subscriber availability is defined as the availability between any two data or voice subscribers between SAS/RTU to reporting Control Centres and between control centres.

The calculated availability is defined as the theoretical availability determined by a statistical calculation based on the mean-time-between-failure (MTBF) and the meantime- to-repair (MTTR) of the components and subsystems comprising the FOTS. The down time of the fibre optic cable shall not be considered in the aforesaid availability calculations.

In order to ensure that the equipment and configuration proposed by the Tenderers shall capable of demonstrating the specified availability figures it is required that the Tenderer shall include in their proposal a calculated availability analysis for the proposed equipment/sub system. 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. The analysis shall be based on an availability block diagram and shall include the mean-time-between-failure (MTBF) and mean-time-to-repair (MTTR) of all the components on the link. The Tenderer shall indicate in the analysis the MTBF and MTTR and the resulting availability of each poini-to-point link. For this analysis, an MTTR of at least 4 hours shall be assumed.

The Tenderer shall carry out the survey at respective Sub-Stations and other linking Sub-Stations to assess the requirements. The required wiring and cabling for the integration with new & existing OPGW systems, new & existing Fibre Optic System, new and existing EPAXs, space requirements, power supply requirements. Placing of proposed FOTS equipment with FODP shall also be assessed by the Tenderer during the Site Survey.

29.6.3.5 Revision Levels and Modifications

All hardware, firmware and software delivered as part of the communications network shall be field proven and at the most of current revision level. All modifications and changes necessary to meet this requirement
shall be completed prior to the start of the factory tests or under special circumstances, on written approval by Employer, prior to the completion of SAT.

29.6.3.6 Equipment Capacities

Equipment supplied shall be sized and equipped with sufficient capacity to support BOQ and configuration requirements as identified in the appendices. Each subsystem supplied shall be sized (to be equipped as specified) to support full subsystem expansion. Data communications channelization required to support the NMS subsystems specified in Technical Specifications (TS) are not identified in the appendices. Therefore, the Contractor is required to size and equip the system to include all channelization and channel cards required to support the NMS function.

29.6.3.7 Redundancy Requirements and Protection Schemes

Equipment redundancy and Automatic Protection Schemes (APS) are specified in the Table 2-1. The failure of one element shall not prevent the use of any other that has not failed.

Table 2-1
Equipment Redundancy Requirements Summary

Fiber Optic transmission Equipment : **SDH equipment**	
Power Supply & Converters ------------------------	1:1 APS
Common Control* Cards --------------------------	1:1 APS
Common control cards which are essentially required for operation of the equipment.	1:1 APS
DACS(Cross Connect)-------------------------------	1:1 APS
Power Supply--	1:1 redundant
Multiplexer power supply--------------------	1:1 APS

The offered equipment shall support at least SNCP **as per standard ITU-T G.841**. In case the equipment offered by the Tenderer does not support the above mentioned minimum protection methods, the tenderer shall have to provide all additional equipment needed to provide same level of flexibility, redundancy and functionality at no additional cost to Employer. The tenderers shall provide details of protection schemes supported in the Bid document.

The offered equipment shall support automatic switchover function between the redundant modules and all required modules and hardware to support the automatic switch over shall be provided by the Contractor.

29.6.3.8 Lost Signal Recovery

At any digital signal level, reapplication of a lost signal shall result in automatic resynchronization and full restoration to normal operation without manual intervention. All alarms incident to the signal failure, shall be automatically cleared at the equipment, rack and monitoring levels and normal operation indications restored and reported if applicable.

29.6.3.9 Software Upgrades

The Contractor shall provide antivirus software along with all the computer hardware/software which shall be upgraded periodically till the maintenance services contract in the bid. Further, to meet all the specifications requirements during implementation and maintenance, if upgrade in the hardware/software of supplied item is required, the same shall be done by the contractor without any additional cost to the Employer.

29.6.3.10 General Site Considerations

In order to meet the link budget requirement, the Contractor shall provide all the necessary equipments only in the end stations. The contractor may provide the optical amplifier, wave length translator, optical cards or high capacity SDH equipment with suitable rack/subrack to meet the maximum distance limit. All the provided equipments shall be monitored by centralized NMS.

29.6.3.11 Proposed Optical Fibre Characteristics

The link budget calculations and equipment design shall be based on the specified fibre parameters. The optical cables shall have Dual Window Single Mode (DWSM) fibres conforming to ITU-T Recommendations G.652D and the major parameters of these optical fibre(s) are defined in Table-2-2:

Table-2-2 Optical Fibre Characteristics	
Fibre Description:	Dual-Window Single-Mode (DWSM)
Mode Field Diameter:	8.6 to 9.5 µm (±0.6 µm)
Cladding Diameter:	125.0 µm + 1µm
Mode field Concentricity Error:	≤ 0.6µm
Core-Clad concentricity error:	≤ 1.0µm
Cladding non-circularity	≤1%
Cable Cut off Wavelength:	≤1260 nm
1550 loss performance	As per G.652D
Proof Test Level	□□0.69 Gpa
Attenuation coefficient	@1310nm ≤ 0.35 dB/Km @1550nm ≤0.21 dB/Km
Attenuation variation with wavelength 1285 nm - 1330 nm 1525 nm – 1575 nm	 Attenuation coefficient @1310 ± 0.05 dB Attenuation coefficient @1550 ± 0.05 dB
Point discontinuities	≤ 0.1dB
Chromatic Dispersion; Max.: **Zero Dispersion Wavelength:** **Zero Dispersion Slope:**	18.0 ps/(nm x km) @ 1550 nm 3.5 ps/(nm x km) @ 1288-1339nm 5.3 ps/(nm x km) @ 1271-1360nm 1300 to 1324nm 0.092 ps/(nm2xkm) maximum
Polarization mode dispersion coefficient	< 0.2 ps/km^1/2
Temperature Dependence:	Induced attenuation < 0.05 dB (-60 deg C - +85 deg C)

Bend performance:	@1310nm (75+2 mm dia Mandrel), 100 turns; Attenuation rise □□0.05 dB @1550nm (30+1 mm dia Mandrel), 100 turns; Attenuation rise □□0.10 dB @1550nm (32+0.5 mm dia Mandrel), 1 turn; Attenuation rise □□0.50 dB

29.7.0 **Fibre Optic Link Lengths**

The fiber optic route lengths are as specified in appendices/Section Project/BoQ. 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.

29.7.1 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-16 and equipped with 2 nos. Of minimum 63 port E1 interface (G.703) card, two no. of m inimum 8 port Ethernet interface (IEEE 802.3/IEEE 802.3u) card supporting layer 2 swit ching as tributaries. The Ethernet interfaces shall support VLAN (IEEE802.1P/Q), s panning tree (IEEE 802.1D) quality of service. Protection scheme for Ethernet traff ic 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.

29.8.0 SDH Equipment

29.8.1 Functional Requirement

There is a requirement for different types of equipment under this project which are described in this section. The Price schedule shall be referred for BOQ. For the purpose of BOQ, the SDH Equipment is considered to be divided in three parts i.e. Optical interface/SFP, Tributary Cards (Electrical tributaries such as E1 & Ethernet 10/100 Mbps) and Base Equipment (Consisting of Common Cards, Control Cards, Optical base card, Power supply cards, sub rack, cabinet, other hardware and accessories required for installation of equipment i.e. everything besides optical interface/SFP and tributary cards).

If tenderer 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.

29.8.2 SDH ADM

The aggregate interfaces shall be STM-16 towards at least 5 (five) protected directions (Protected as specified in this specifications). At present the equipment shall be equipped with a 2 nos., min. 63 E1 port electrical tributary cards & one no., min. 8 port Ethernet interface card as tributaries. The equipment shall provide access to full STM16 payload. The equipment shall provide non blocking cross connect capability of 64 STM-1 (bi-directional) at high order VC-4 level and as well as low order VC-12 level. Cross connection (VC4) capability of offered SDH equipment shall be provided according to STM-16 equipment.

29.8.3 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.

29.8.4 Service Channel

Service channels shall be provided as a function of the SDH equipment and shall be equipped with Service Channel Modems that shall provide at a minimum: 8 voice channel (order wire) with analog interface (0.3 to 3.4 kHz) and 4 data channel with opto coupler interface for V.24/V.28 interface. 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.

29.8.5 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 NMS.

29.8.6 Synchronisation

The equipment shall provide synchronisation as per Table 2-2. One 2MHz synchronisation output from each equipment shall be provided.

29.8.7 Electrical and Optical I/O Characteristics and General Parameters

Table 2-3 provides the electrical and optical characteristics as well as other general parameters for SDH equipment.

Table 2-3 **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.

29.9.0 Optical Link Performance Requirements

The optical fibre link performance requirements are specified as follows:

29.9.1 Link Budget Calculations

The fibre optic link budget calculations shall be calculated based upon the following criteria:

(1) Fibre attenuation: The fibre attenuation shall be taken to be the guaranteed maximum fibre attenuation i.e. 0.21 dB/Km @1550nm and 0.35 dB/km @1310nm.

(2) Splice loss: Minimum 0.05 dB per splice. One splice shall be considered for every 3 kms.

(3) Connector losses: Losses due to connectors shall be considered to be minimum 1.0 dB per link.

(4) Equipment Parameters: The equipment parameters to be considered for link budget calculations shall be the guaranteed “End of Life (EOL)” parameters. In case, the End of Life parameters are not specified for the SDH equipment, an End of Life Margin of at least 2 dB shall be considered and a similar margin shall be considered for optical amplifiers.

(5) Optical path Penalty: An optical path penalty of at least 1 dB shall be considered to account for total degradations due to reflections, inter symbol interference, mode partition noise and laser chirp.

(6) Maintenance Margin: A maintenance margin of at least 2.5 dB/100Km shall be kept towards cabling, repair splicing, cable ageing and temperature variations etc.

(7) Other losses: Other losses, if any required specifically for system to be supplied shall also be suitably considered.

(8) Dispersion: The fibre dispersion shall be taken to be the guaranteed maximum dispersion i.e. 18 ps/nm.Km @1550 nm & 3.5 ps/nm.km @ 1310 nm for DWSM fibres.

(9) Bit Error Rate: The link budget calculations shall be done for a BER of 10^{-10}.
The tenderers 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.

29.9.2 Link Performance

The Link performance for ES, SES and BER for the fibre optic links shall correspond to National Network as defined in ITU-T G.826.

FOTS equipments shall be provided with in-built loopback capabilities : Each FOTS transceiver pair shall be able to provide local(manual) and remote on demand loopbacks of the composite baseband and each E-1 port.

29.10.0 FODP to SDH Equipment

The Contractor shall be responsible for connectivity between the FODP(to be provided under separate contract) and the SDH equipment. The Contractor shall provide FC PC coupled patch cords of suitable length as per requirement. The patch-cord length between the FODP & equipment rack shall be suitably protected from rodents, abrasion, crush or mechanical damage.

29.11.0 DDF and Cabling

For the purposes of the specification, the contractor shall provide cabling, wiring, DDF patching facilities to the wideband telecommunications system. Equipment and material components for 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 and shall be in accordance with communications industry standard practices and the requirements mentioned in the technical specifications.

29.12.0 Digital Distribution Frame Functional Requirements

The Contractor shall provide DDF for Digital Signal Cross connect (DSX) Broadband-quality (better than 20 MHz) patching facilities configured "normally-thru" with Equipment, Line and Monitor Patch Jacks. DDFs shall provide the following basic functions:

(i) "Normally thru" circuit routing
(ii) Circuit rerouting via patch cord assemblies
(iii)Circuit disconnect and termination

All DDFs shall be sized and equipped to support the offered configuration of the provided equipment. Independent Transmit and Receive patch jack assemblies (line and equipment) shall provide for separate transmit and receive single-plug patching. Transmit and receive patch jack assemblies shall be located side-by-side such that dual-plug patch cord assemblies may be used to route both transmit and receive for the same circuit.

29.12.1 Patch Cords

The Contractor has to supply FC PC coupled Patch cords as described in BOQ. The Patch cord return loss shall be equal to or better than 40 dB and insertion loss equal to or less than 0.5 dB.

29.13.0 Telecommunication Management Network / Network Management System

The Contractor shall provide Craft Terminal based Telecommunications Management Network System (NMS) for operational support to the FOTS subsystems (if required). This NMS shall provide the capability to monitor, reconfigure, and control elements of the telecommunications network with the help of a portable personal computer to be known as craft terminal. The Contractor shall submit for Employer's approval the NMS architecture describing in detail the following subsystems/features:

(a) Database used in NMS
(b) Peripherals and hardware
(c) Software and operating system
(d) Craft Terminals

29.14.0 Management Functions

The NMS shall support following Management functions:

29.14.1 Configuration Management

Configuration management is concerned with management, display, and control of the network configuration. Minimum specific requirements that shall be satisfied include the following:

a. Provide tools to establish and maintain the backbone topology and configuration information and provide graphical maps depicting the configurations.

b. Gather descriptive information about the current configuration of the equipment, provide operator displays, and prepare reports.

c. Provide tools for planning, establishing, and changing the static equipment configuration. Provide for changes to the equipment configuration in response to equipment failures, planned upgrades, and operator requests to take equipment offline for testing.

d. Provide verification testing to support new equipment installation.

29.15.0 Fault Management

Fault management is concerned with detecting, diagnosing, bypassing, directing service restoration, and reporting on all the backbone network equipment, systems, and links. Minimum specific requirements that shall be satisfied include the following:

a. Display equipment status in a consistent fashion regardless of the source of the data on a graphical topological, map-type display. Status shall be displayed through the use of colours on links and nodes as well as through text.

b. Obtain status and detect faults through periodic polling, processing of unsolicited alarms and error events, and periodic testing for connectivity.

c. Maintain an alarm summary of unacknowledged alarm events on the management station display and maintain a log of all received alarms. The operator shall be able to acknowledge and clear alarms individually and as a group. The use of alarm correlation techniques is encouraged to minimize the proliferation of alarms caused by a single, common event. All alarms shall be configurable as critical alarms, major alarms and minor alarms with different colours.

d. Provide the capability to diagnose and isolate failures through analysis of error and event reports and through the use of both on-line and off-line diagnostic tests and display of monitored data.

e. The criteria for fail over shall be configurable as automatic fail over to redundant equipment wherever possible and through operator-initiated actions where automatic fail over is not possible. The status of fail over shall be reported to the NMS.

f. Track network equipment failure history.

29.16.0 Performance Management

Performance management is concerned with evaluation of the use of network equipments and their capability to meet performance objectives. Minimum specific requirements that shall be satisfied include the following:

a. Provide support for an operator to initiate, collect, and terminate performance metrics under both normal and degraded conditions. For example, BER of each link, together with other data measured at each node, shall be available on operator request.

b. Monitor point to point & end to end signal quality and history. Provide operator controls to monitor performance of specified events, measures, and resources. Specifically provide displays to permit the operator to:

1. Select/deselect network equipments, events, and threshold parameters to monitor
2. Set monitoring start time and duration or end time
3. Set monitoring sampling frequency
4. Set/change threshold values on selected performance parameters
5. Generate alarm events when thresholds are exceeded.
6. Set multiple thresholds on certain performance parameters. Alarm categories include as a minimum a warning and a failure.
7. Calculate selected statistical data to measure performance on selected equipment based on both current and historical performance data maintained in performance logs. Performance data provided is limited to what is available from the equipment Contractors.
8. Provide graphical displays of point to point and end to end current performance parameter values. Provide tabular displays of current, peak, and average values for performance parameters.
9. Generate reports on a daily, weekly, monthly, and yearly basis containing system statistics.

29.17.1. Security Management

The NMS 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 NMS 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.

29.17.2. Communication Channel Requirement and Integration

Communication requirements for NMS system have not been considered in Appendices and the Contractor shall provide these as a part of NMS system. The Contractor shall provide all required interface cards / devices etc. The NMS data transport shall utilize the wideband communications transmission system service channel in the overhead whenever possible.

29.18 Craft Terminal

Each equipment 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

29.19 Hardware Requirements

29.19.1 Craft Terminal

The 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 Craft Terminal shall be a laptop. The craft terminal shall have the following minimum configuration:

Parameter	Specification
Compliance	MIL-STD 461F, MIL-STD 810 G
Display	14.0” FHD (1920 x1080)
	1000 nits DynaVue® sunlight readable display with capacitive multi-touch screen
	User selectable touch mode for Finger/Water, Glove, or Stylus programmable function
Operating System	Windows® 10 Pro 64-bit
Processors	Intel® Core™ i7-1185G7 vPro™ (11th Gen) 3.0GHz processor with Turbo Boost Technology up to 4.8GHz, 12MB cache
Memory	2 slots 8GB (3200MHz DDR4)
Storage	Main: 1TB NVME PCIE SSD
Graphics	Intel® Iris® Xe Graphics
Camera	Integrated 2.0 MP web-cam with shutter design
	Optional IR camera for Windows Hello1
Audio	Integrated microphone
	Intel® High Definition Audio Compliant
	Integrated speaker x 2
	Keyboard volume and mute controls
Media Bay (One Option Only)	Optional DVD super Multi Optional 2nd battery Optional SATA SSD
Expansion Box	Optional PCI-Express 3.0 (2 slots)1,6

	Optional discrete VGA1,6
	Optional storage extension with RAID 0/1/5/101,6
	Optional military-grade connectors1
I/O Ports	Thunderbolt 4 (type C) x 1
	USB 3.2 Gen2 (type C) x 1 (support DP)
	USB 3.2 Gen2 (type A) x 1
	USB 3.2 Gen1 (type A) x 1
	USB 2.0 (type A) x 1
	Audio in/out (combo jack) x 1
	microSD card (microSDXC) x 1
	10/100/1000 Ethernet (RJ45) x 2
	VGA port (D-sub,15-pin) x 1
	HDMI port (type A) x 1
	Serial port (RS232 : D-sub,9-pin) x 25
	Docking connector (41-pin Pogo) x 1
	SIM card x 1
	Smart card reader x 1
	DC-In jack x 1
	ExpressCard 54 x 1 (default) or PCMCIA Type II x 1
	Optional RF antenna pass-through for GPS, WWAN, and WLAN
Keyboard & Pointing Device	2 user-definable keys (P1/P2)
	RF signal slide-switch
	Standard membrane keyboard with LED backlight
Communications	Integrated 10/100/1000 Ethernet
	Intel® Wi-Fi 6 AX201 (802.11 ax)
	Bluetooth® V5.2
	Optional dedicated GPS module (UBLOX-NEO-M8N)
	Optional 4G LTE multi-carrier mobile broadband
	Optional RF antenna pass-through for GPS, WWAN, and WLAN
Security	Intel® vPro™ Technology (per CPU options)
	TPM 2.0
	NIST BIOS compliant
	Easy removable SSD
	Smart card reader
	Stealth mode
	Night vision mode
	Kensington lock
	Optional Windows Hello1
	Optional fingerprint scanner

	Optional HF/LF RFID reader1
Power	AC adapter : 100-240V, 50Hz-60Hz, 90W
	Optional AC adapter (100-240V, 50Hz-60Hz, 120W), with NVIDIA® VGA
	Main battery Li-Ion, 10.8V, 7800mAh, 16 hours2
	Optional 2nd battery Li-Ion 10.8V, 4700mAh, 9 hours2
	Optional bridge battery : 5 minutes swap time3
Dimension & Weight	356 mm (L) x 280 mm (W) x 50 mm (H)4
	3.6 kg
Warranty	3-year limited warranty standard

29.19.2 Power Supplies

The NMS 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.

29.20 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.

29.20.1 Operating System Software

Operating system software shall be provided to control the execution of system programs, application programs, management devices, to allocate system resources, and manage communications among the system processors. The contractor shall make no modifications to the OEM's operating system, except as provided as USER installation parameters.

29.20.2 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.

29.20.3 Software Utilities

A utility shall be provided to convert all reports into standard PC application formats such as excel.

29.20.4 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.

20.5 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 NMS system.
NMS 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.

29.20.6 Help

All applications shall be supported by USER accessible HELP commands that shall assist the user in the performance of its tasks. HELP commands for an application shall be available to the user from within the active application and shall not interfere with the activities of the application.

29.21 Environment, EMI, Power Supply, Cabling and Earthing

The purpose of this section is to describe the minimum general equipment characteristics and specifications for environmental conditions, source power conditioning and backup, equipment construction, and installation. The section also highlights the stringent Electro Magnetic Compatibility (EMC) guidelines for equipment that will be operated under the severest Electro Magnetic Interference (EMI) and Electro Static Discharge (ESD) conditions expected in an Extra High Voltage (EHV) power system environment.

29.21.1 Environmental Requirements

Equipment and their components provided under this specification shall operate reliably under the following environmental conditions.

29.21.1.1 Temperature and Humidity

Most of the equipment will not be installed in environmentally controlled shelters. Therefore, equipment shall operate in accordance with the limits shown in Table 4-1.

Table 4-1
Environmental Operating Limits

Temperature Range: **Specification** **Operation without damage** **Shipping/storage**	(Un Controlled Environment) 0 to 45°C -10 to 55°C -40 to 60°C
Relative Humidity, non-condensing	Upto 90%
Elevation: **Operating** **Non-operating**	 to 3,000 m to 10,000 m

For each location, the Contractor is required to assess the environmental conditions for the equipment to be installed under this specification. The Contractor is responsible for all necessary enclosure, rack or equipment upgrades to ensure the proper operation of the installed equipment.

29.21.2 EMI and Electrostatic Interference

At each location, the Contractor shall assess the need for shielding against radiated emissions and shall provide recommended solutions for any EMI problem found at each location. Specifications provides the type of immunity tests for which the equipment shall be required to pass without failure. For the individual tests to be carried out at the different interfaces, references are made to the relevant IEC and ITU-T recommendations.

29.21.3 Vibration and Shock Resistance

As per testing requirements indicated in this specification.

29.21.4 Tropicalization

Communications equipment will often be stored and operated in uncontrolled environment areas and will be subject to mould, growth of fungus, corrosion and oxidation. The equipment and components shall be suitably tropicalized during manufacture through commissioning, as necessary.

29.21.5 Contaminants

Communications equipment may be located in areas of poor air quality with the main contaminant being dust. Cabinets shall be tight fitting utilizing filtered ventilation openings only.

29.22.0 Primary Source AC/DC Power Requirements

Facilities will be required to support both AC and DC power load requirements of telecommunications equipment as specified below:

29.22.1 Primary Source AC Power

It will be the Employer's responsibility to provide required Primary AC source Power for communications equipment installed under this specification. The Primary AC Power supplied will be 240 VAC ± 10%, 50Hz with a frequency variance between 46 and 55 Hz. Harmonic distortion will not exceed five (5) percent. All equipment and components provided under this specification requiring Primary AC Power, shall be designed for normal operation under the above stated tolerances for 240 VAC supply. The Contractor shall provide in their Bid as well as in the survey report to the Employer the projected 240 VAC Primary Power load requirement per equipment and totals, by location, for equipment provided under this specification. The Contractor shall provide suitable UPS for communication equipment/module etc. requiring AC power supply at locations other than control centre.

29.22.2 -48V DC Power

Power supplies/converters for communications equipment (except computer system supplied as part of NMS which shall use 240 VAC) provided under this specification, shall use -48Vdc uninterrupted primary source power. **The 48V SMPS battery charger and 48V battery bank for all the 220KV and 132KV substations that fall under this network shall be supplied by the contractor.** The power supply may vary normally within the voltage range -42 to -58 Vdc and the supplied equipment shall operate satisfactorily within this range.

29.22.3 TECHNICAL SPECIFICATION 48V BATTERY BANK FOR FOTE (If Required)

29.22.3.1 **TYPE AND RATING**

i) Stationary type, sealed, valve regulated lead acid battery tank suitable for operation on 48 Volts D.C. system to meet loads like emergency lightning, control and signaling circuits, relays, breaker operations, indicating circuits, etc. shall be required. The stationary battery shall comply with the provisions of IEC 896, Part 2 / ANSI T1.330.
ii) The Ampere-hour capacity of the battery bank at 27°C at 10 hours discharge rate shall be 100/200 AH.
iii) The nominal voltage of the battery bank shall be 48 Volts D.C.
iv) The number of cells in a complete battery bank set shall be 24 plus 2 spares.

29.22.3.2 **PLATES**

Positive plates shall be made of flat pasted type using lead-cadmium antimony alloy for durability, high corrosion resistant, maintenance free, long life both in cyclic as well as in ,float applications. Negative plates shall be heavy duty, durable flat plate using lead calcium alloy pasted box grid. Negative plates shall be designed to match the life of positive plates and combination of negative and positive plates shall ensure long life, durability and trouble free operation of battery. PLC operated equipment should be deployed for preparation of paste to ensure consistency in paste quality. Conventional / manual type of paste preparation is not allowed.

29.22.3.3 **CONTAINER AND LID**

The containers and lids shall be made of a special grade polypropylene copolymer plastic material. They shall be sufficiently robust and not liable lo deformation under internal operating pressures and within the temperature range naturally encountered, leak proof, non-absorbent and resistant to the acid with low water vapour permeability.

29.22.3.4 **VENT PLUGS**

Each cell shall be equipped with one-way safety valve with opening pressure of 5±1 psi and closing pressure 4±1 psi. The vent plug shall be made with suitable grade of fire retardant plastic material. Each valve opening shall be covered with flame barrier capable in preventing the ingress of flame into the cell interior when the valve opens and hydrogen / oxygen gas mixture is released.

29.22.3.5 **SEPARATORS**

Separator shall be made of spun glass, micro porous matrix and shall be resistant to Sulphuric Acid. It shall be capable of keeping the entire electrolyte and shall be electrically insulated. Sufficient separator overlap and PVC shield protection to top and bottom edges of the plates is to be provided to prevent short circuit formation between the edges of adjacent plates.

29.22.3.6 **CONNECTORS**

The connectors shall be lead coated copper of suitable size to join the cells. The connectors shall be suitably designed and coated to withstand corrosion due to sulphuric acid. The coating should be adequate and tenacious. All the copper inter cell connectors shall be provided with heal shrinkable sleeves except at the connecting points.

29.22.3.7 **ELECTROLYTE**

The electrolyte shall be prepared from the battery grade Sulphuric Acid confirming to ISS: 266. The batteries shall be supplied in factory filled and charged condition.

29.22.3.8 **WATER**

Water required for preparation of electrolyte shall conform to IS: I069.

29.22.3.9. **PLATE CONNECTION**

Lugs of plates of like polarity shall be connected by lead burning to a horizontal strap having an upstanding terminal post adopted for connection to external circuit. Strap and post shall be caste with lead alloy. The positive and negative terminal posts shall be clearly marked for unmistakable identification.

29.22.3.10 **BOLTS AND NUTS**

Nuts and Bolts for connecting the cells shall be of superior grade passivated Stainless steel.

29.22.3.11 **TERMINALS**

Terminals shall be of integral lead terminal with solid copper core with M6 threading for fastening. The junction between terminal posts and cover and between the cover and container shall be hermetically sealed

29.22.3.12 **BATTERY RACKS** ...

Batteries shall be installed on MS racks to be supplied by the Contractor to fit in the battery room. Racks/Trays shall be powder coated with anti-corrosive paint. Rack shall accommodate 55 cells plus 2 spares. Racks/Tray shall be suitably treated before painting for protection against fungus growth and other harmful effects due to tropical environment. The colour of the supporting racks shall conform to RAL 7032 shade.

29.22.3.13 CAPACITY REQUIREMENTS:

When the battery is discharged at 10 hour rate, it shall deliver 80% of Rated Capacity (corrected at 27°C) before any of the cells in the battery bank reaches 1.85 V/cell. The battery shall be capable of being recharged from the fully exhausted condition (1.75 V/cell) within 10hrs upto 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 that Rated capacity & not more that 120% of Rated capacity before any cell in the battery bank reaches 1.75 V/cell. The battery voltage shall not be less than the following values, when a fully charged battery is put to discharge at a rate of 1/10th of the Rated Capacity:

(a) After SIX hours of discharge: 1.92V/cell
(b) After EIGHT hours of discharge: 1.85V/cell
(c) After TEN hours of discharge: 1.75V/cell

Loss in capacity during storage at an average ambient temperature of 35°C 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%. However, the battery to be manufactured and to be delivered at site in such a way that load can be connected with the battery within 15 days from the date of installation. Date of initial charging is to be mentioned on the battery.

29.22.3.14 ASSOCIATED EQUIPMENTS & ACCESSORIES (For each set of battery) :

a) Best quality metallic stand/frame as per Clause 9.12.
b) Stand insulators +5% extra
c) Inter row connectors :Appropriate quantity
d) Inter tier connectors
e) Centre-zero (3-0-3) volts DC Voltmeter : 1 No
f) Torque wrench/ Spanners : 1 No
g) Connection hardwares, such as strips, bolts, nuts(with 5% extra)
h) Cable clamps with hardware
i) Cell numbering tags with fixing arrangement
j) Two sets of special tools and tackles for connecting terminals of the battery
k) Any other accessories not specified but required for satisfactory operation.

29.22.3.15 TYPE TEST OF BATTERY:

The Tenderer/ Supplier shall supply type tested battery as per IS 15549:2004/ IEC 60896-21 & 22 over the range of at least one capacity per design. The Tenderer/ Supplier shall submit necessary evidences enclosed along with tender documents.

Sl No	DESCRIPTION
1	Gas Emission
2	High Current Tolerance
3	Short Circuit Current & DC Internal resistance
4	Protection against Internal Ignition from External Spark source
5	Protection against Ground Short Propensity
6	Content & Durability of required marking
7	Material Identification
8	Valve Operation
9	Flammability Rating of Material
10	Intercell Connector Performance
11	Discharge Capacity
12	Charge Retention during Storage
13	Float Service with Daily Discharge for reliable mains power
14	Recharge behaviour
15	Service Life at an operating temperature of 40°C for brief duration exposure time

16	Impact of Stress Temperature of 60°C for brief duration exposure time with 3hrs discharge test
17	Abusive Over Discharge
18	Thermal Runaway Sensitivity
19	Low Temperature Sensitivity
20	Dimensional Sensitivity at Elevated Internal Pressure & Temperature
21	Stability against Mechanical abuse of units during installation

29.22.3.16 Routine Test:

(i) Physical Examination Test
(ii) Visual Inspection
(iii) Dimensions, Mass & Layout
(iv) Marking & Packing

29.22.3.17 ACCEPTANCE TEST OF BATTERY

(i) Polarity Marking
(ii) Verification of Dimensions
(iii) Open Circuit Voltage of each Cell & Total Open Circuit voltage of the battery bank
(iv) Test of AH Capacity

29.22.3.18 LIST OF FACTORY & SITE TESTS FOR BATTERY

Sl. No.	TEST	FACTORY TESTS	SITE TESTS
1	Physical Verification	YES	YES
2	Capacity Test on the cell at 1/10th of Rated Capacity, corrected at 27°C	YES	
3	8hrs Charge & 15mins Discharge Test at Full Rated Load	YES	

29.22.4 48V BATTERY CHARGER

29.22.4.1 General:

This section covers the general requirement of 48 V DC SMPS Based Power Plants, based on High Frequency Switch Mode Techniques using switching frequencies of 20KHz and above for use in AEGCL.

29.22.4.2 SMPS Based Power Plants is intended to be used in **Auto Dual Float Rectifier cum Boost Charger (FR-BC)** mode as a regulated DC Power Source.

29.22.4.3 **Power System Configuration**:

The configuration of 48 V DC Power Plants with FR-FC & FRBC Modules shall be as under:

Sl No	Basic SMR Module	Configuration	Permissible Ultimate Capacity
1	25 A FR-FC	(n+1)	75 Amp
2	50 A FR-FC	(n+1)	150 Amp
3	25 A FR-BC	(n+2)	75 Amp
4	50 A FR-BC	(n+2)	150 Amp

The FR-FC or FR-BC modules shall be housed in (n+1) or (n+2) parallel configuration in a single rack where ‘n’ is the actual required number of FR-FC, FR-BC modules for meeting the particular load requirement.
AEGCL shall indicate the Type, Number and Configuration of SMR Modules, depending upon the load requirement. AEGCL shall also indicate Ultimate Expandable Capacity considering future expansion requirement.

29.22.4.4. The Battery Charger of 48V/25A (Ultimate capacity 150A) or 48/50A (Ultimate capacity 150A) N+1 configuration shall be of SMPS type and shall be chosen as per load demand of communication equipments of the substations. The system shall consist of DSA and Float Rectifier –cum-Charger (FR/FC) in a steel rack in a modular type. It should have menu driven microprocessor control technique for DSA as well as module for control, monitoring and alarm to achieve better reliability of the system.

29.22.4.5 **Rack Configuration :**

Rack is composed of following units accommodated in sub racks

a) Dual Float Rectifier cum Boost Charger (FR-BC) Modules.

b) Distribution-Switching-Control-Alarm Arrangement (DSCA)

c) The number and rating of FR-FC, FR-BC Modules shall be provided as per purchaser’s requirement. The Distribution-Switching-Control-Alarm Arrangement (DSCA) shall be provided for the Ultimate Expandable Capacity. All factory wirings for the rack shall be for the Ultimate Expandable Capacity so that only plugging-in of FR-FC or FR-BC module shall enhance the DC Power output.

29.22.4.6 **Parts & Components**

The Parts & Components including Fuses and Circuit Breakers for manufacturing of the SMPS Based Power Plants shall be of Industrial Grade. These Parts & Components shall be procured from reputed manufacturers to ensure prompt and continuous service and delivery of spare parts.

Power Transformers and Chokes shall use Class B or Higher Grade of insulation. The Transformers and Chokes shall be wound with copper wire provided with adequate insulation.

Component mounting and fixing methods shall be secured.

29.22.4.7 **Wiring:**

All insulated conductors except those within the confines of a printed circuit board assembly shall be of the rating enough to withstand the maximum current voltage during fault and overload.

All wiring shall be neatly secured in position and adequately supported. Where wires pass through any part of Metal Panel or Cover, the hole through which they pass shall be suitably bushed with rubber grommet.

29.22.4.8 **Bus Bars:**

Bus bars shall be of high conductivity electrolytic copper strips capable to with-stand 1.5 times the maximum load current. The Bus bar shall be capable to carry current density of 2 Amps/mm2 but shall not be less than 25mmx5mm in any case. The size of bus bars chosen for battery and load path shall be capable to take care of the current of maximum power plant capacity for which it is designed.

Bus-bar Riser height wherever applicable shall be 250mm for both load and battery.

Earthing: All non-current carrying metal parts shall be bonded together and earthed. An earth terminal suitable for taking minimum 4 mm dia wire and with suitable marking shall be provided

The SMPS Based Power Plants shall be designed & manufactured for continuous operation at rated load in the ambient temperature range of 0ºC to 55ºC.

Insulation Resistance and Voltage Proof

The insulation resistance of a fully wired FR-FC and FR-BC Modules when tested with a 500V DC Megger shall be as given below:

a) AC input and Earth - Greater than 2 Mega Ohm

b) DC Output and Earth - Greater than 1 Mega Ohm

c) AC input and DC output - Greater than 5 Mega Ohm.

29.22.4.9 **Lightning Protection :**

The SMPS Based Power Plants shall have modular type Type I/Class B and Type II/Class C type surge protection in TT configuration of wiring. Both the Type I/Class B and Type II/Class C arrestors should be from the same manufacture and shall be mounted as per the specific installation recommendations of the manufacturer to achieve perfect coordination.

Radio Frequency Interference Suppression: The module shall be designed to minimize the level of electromagnetic interference (EMI), both conducted and radiated, detected in its vicinity and generated by Switch Mode Power Conversion Equipment operating within the rack.

29.22.4.10 **Name plate :**

A name plat etched/engraved/anodized or any other better arrangement ensuring better life expectancy shall be suitably fixed on each rack/module and contain following information.

1. Specification Number

2. Type of Unit
3. Manufacturer's name and identification
4. Model No.
5. Unit Serial No.
6. Input Voltage and phase
7. Output Voltage and current
8. Year of manufacture
9. Suitable for battery capacity

29.22.4.11 AC input supply: The Power Plant using FR-FC or FR-BC modules of 25 Amps shall operate from single phase AC input and FR-FC or FR-BC modules of 50A capacity may operate from single phase or 3 phase 4 wire AC input. The nominal input frequency is 50Hz which may vary from 48-52Hz. The input voltage range shall be as given below:

a) Single Phase (nominal 230V) :

For Power Plant to be used at stations having reasonable power supply regulation, incoming power supply range shall be from 165 V AC to 260 V AC.

b) Three Phase/4 Wire 400V+10%/ - 15% (Nominal 400V)

29.22.4.12 There shall be an automatic arrangement for shutting off the FR-FC or FR-BC Modules wherever the input voltage is beyond the specified operating limits with suitable alarm indication. It shall resume normal working automatically when the input is restored within the working limits. Hysteresis within specified working limits shall not cause shutting down of the FR-FC or FR-BC Modules. A tolerance of ±5V may be acceptable for protection & alarm operation. All the FR-FC or FR-BC Modules shall switch OFF simultaneously.

29.22.4.13 FR-FC or FR-BC Modules working from 3 phase/4 wire input shall work satisfactorily for unbalance of ±10% of nominal input. The module shall be isolated (if required for the protection of the unit) in the event of unbalance beyond 10% and shall restore when the input is within limits.

29.22.4.14 The SMPS battery charger shall be capable of continuous operation with float voltage 2.23 to 2.25 Volt per cell and 2.3 Volt per cell for charge voltage while supplying the constant DC load.

29.22.4.15 The SMPS battery charger shall have constant voltage characteristics throughout the range (from zero to full load) at floating value of the voltage so as to keep the VRLA batteries fully charged but without harmful overcharge.

29.22.4.16. The float cum boost charger works on 415 V AC, 50 Hz supply (or 230 V AC, 50 Hz supply). The battery charger should be capable of delivering the full rated load at the specified voltage at the output terminals. The set output voltage is maintained for AC input variation of + 10% and load variation from 0-100% of rated full load.

29.22.4.17 The charger voltage in float mode of operation is normally be set at 54 V DC and the same shall be adjustable between 48 and 54 V DC through variable potentiometer. When the charger is selected to boost mode, it should supply charging at the rated current maximum. This shall be adjusted from 20% to 100% of rated current through potentiometer.

29.22.4.18 All these circuits are housed in freestanding cabinet of folded sheet steel (thickness of sheet steel should not be less than 2.5mm) construction finished in stove enamel light gray colour conforming to shade of 631 of IS: 5. The cabinet is provided with front and back doors for easy accessibility. All meters, meter selector switches, control switches and LCD display (Microprocessor unit) etc are to be provided on the front panel. The AC input and DC output MCCB'S and control switches are provided on middle inside of the breaker panel. The cable terminations are provided on front side of the cubicles.

29.22.4.19 PARTICULARS

Type	FLOAT CUM BOOST CHARGER Hot swappable rectifier modules 25A/48V, N+1 configuration.
Rating	48 V (Capacity as per Battery Sizing Calculation) Dual float cum boost charger (suitable for MF-VRLA battery)

AC INPUT		
A	Voltage	415 V AC+ 10% (230V AC +10%)
B	Phase	3 phase, 3 wire (single phase)
C	Frequency	50 Hz+5% (50Hz+2Hz)
D	Power factor	(Better than 0.7 lagging)

DC OUTPUT			
A	Float voltage	:	48 V- 54 V DC
B	Boost voltage	:	48 V-55.2 V DC
C	Output current	:	35A
D	Voltage regulation	:	Better than + 1% of set value
E	Ripple	:	Less than 1% r m s
F	Efficiency	:	(Better than 90%)
G	System output voltage	:	55.2V DC+1%(at load terminal)

METERS	The microprocessor based controller should have metering facilities namely (a) Load Voltage (b) Load Current, (c) Battery Voltage (d) Battery Current (e) Battery Temperature, (f) Voltage and current of individual module.

PROTECTION			
Over voltage trip at the output	:	Over voltage cutback	56.5+ 0.5 V DC
DC under voltage at battery input	:		42+ 0.5 V(1.75 V X 24)
Fuse at AC input	:	Fast acting semiconductor fuse	Fast acting semiconductor fuse
Fuse at DC out put to load	:	MCCB	Fast acting semiconductor fuse
Reverse polarity at	:	Protected	Protected

battery input			
Out put current limiting	:		Battery charging current limit
AC input MCCB	:	Required	Required
Blocking diode	:	Required	Required
Charger over load	:	Required	Required

INDICATION

AC input ON	:	Required
DC output ON	:	Required
Float ON	:	Required
Boost ON	:	Required
AC under voltage	:	Required
AC over voltage	:	Required
DC over load	:	Required
DC over voltage	:	Required
Short circuit	:	Required
Reverse polarity	:	Required
Mains fail		Required
Charger fuse fail		Required
Battery over voltage		Required

CONTROLS AND SWITCHES

AC input MCCB	ON/OFF switch at input
DC output MCCB	Three way switch to select auto / manual float / manual boost operation
Auto/manual float/boost mode selector switch	Two way switch to read charger output current or battery charge / discharge current
Auto /manual voltage regulator selector switch	Single tern potentiometer for float voltage adjust
Float and boost voltage variable potentiometer	Single tern potentiometer for boost voltage adjust
Manual voltage adjust variable potentiometer	Single tern potentiometer for charger total current adjust
Battery current adjust potentiometer	Single tern potentiometer for battery current adjust
Heaters power supply switch	
Socket power supply switch	
ADDTIONAL FEATURES	
Soft start on DC side	Auto float / boost operation

29.22.4.20

a). The Battery Charger shall have Dual Source AC Input (AC Input 1 and AC Input 2) with individual MCCB and shall be provided with Auto Changeover arrangement.

b). The Battery Charger shall have an IP Rating of IP42 or better. The Charger shall be type tested for IP42 or better rating.

29.22.5 Power Distribution and Protection

The Employer will furnish only one source primary 240 VAC. It shall be the Contractor's responsibility for the connection and distribution of all Primary AC and 48V dc source power, in full compliance with all local and national electrical codes.

The Employer shall indicate during the survey by Contractor, on the primary source, the feeders/points that can be used by the Contractor. The Contractor shall supply & install Primary AC and -48Vdc feeder cables to Contractor-furnished distribution panels.

The Contractor shall provide required distribution panels, circuit breakers and appropriate Panel Disconnects. Distribution Panel feeders, Panel Disconnects, distribution panels and circuit breakers shall be sized and equipped to support at least 100% expanded load requirements.

The Contractor shall provide and install all required primary power distribution sourced from the distribution panels. The Contractor shall also be responsible for Load Balancing.

The Contractor is responsible for all inter-rack (enclosure) and intra-rack (enclosure) power distribution required to support equipment supplied under this specification. The Contractor shall provide all cabling, fusing, switching and circuit breaker and surge protection required.

Partially equipped subsystems shall be installed with provision for expansion. Equipment power supplies provided under this specification, shall be sized to support fully equipped subsystems. Primary power distribution protection shall be sized to support and protect maximum operating load potential whether or not the actual projected load shall meet that maximum load potential.

The Contractor shall provide equipment and rack safety earthing in compliance with this specification.

29.23.0 Equipment Construction, Assembly and Installation

All equipment supplied under this specification shall be constructed, assembled and installed in accordance with the following requirements:

2.23.1 Identification

All cabling, racks/enclosures, equipment, modules and materials shall be uniquely identifiable as per the following:

2.23.2 Equipment

Each equipment component to the level of printed circuit card, shall be clearly marked with the manufacturer's part number, serial number, month/year of manufacture and revision level. Changes to components shall be identified by an unambiguous change to the marked revision level. The Contractor shall be responsible for maintaining the master revision level list until the Contractor has complied with all requirements of this specification. Where custom components and parts are provided, each component/part shall be marked to specifically identify that component/part. Printed circuit card cages are defined as an equipment component and as such, shall be clearly identified as stated within this specification. Equipment chassis and printed circuit card cages having wired back-planes, shall be clearly marked with the manufacturer's part number, serial number, month/year of manufacture, revision level and an additional identifier corresponding directly to the applicable backplane wiring diagram/list.

2.23.3 Power Distribution

Power distribution panels shall be clearly marked with their unique identifier, source feed information, and remote source feed emergency disconnect location and identity.
Power distribution panel "Main Disconnect" and circuit breakers shall be clearly marked with aunique identifier. Circuit breaker feed lists shall be clear, accurate and the feed list information shall be posted inside each distribution panel door.
Inter-rack and intra-rack (enclosure) power distribution shall be clearly identified with source feed, voltage and power rating information. All power feed cabling shall be clearly identified near the point of termination.
All power distribution identification shall utilize heat-resistant permanent marking techniques such as stamped non-metallic tags, embossed labels, etc. Marking techniques are subject to approval by the Employer. Power distribution identifiers and information shall agree with the Contractor's power cable plant drawings.

2.23.4 Signal Cabling

Connectorised signal cabling/wiring requires marking with a unique identifier at each connectorised end. The signal cable/wire identifier shall include a cable identifier and the location of both terminations.
Signal cable/wiring installed on terminal blocks requires marking with the cable identifier and distant end location. The cable tag shall be clearly visible at the cable fanout point.
All signal cable, wiring and terminations shall be clearly labelled/tagged with identifiers consistent with Contractor supplied cable plant records. Marking techniques are subject to approval by the Employer.

2.23.5 Equipment Racks and Enclosures

All equipment racks, enclosures and equipment, including distribution frames, shall be clearly labelled with unique identifiers consistent with Contractor supplied floor plans and rack elevations.

2.24.0 Installation Hardware

Equipment racks, enclosures, cable raceways and installation hardware shall, at a minimum, comply with the following requirements:

2.24.1 Equipment Sub-Racks and Cabinets (Enclosures)

All equipment provided under this specification, shall be physically mounted in sub-racks andcabinets (enclosures). The Contractor shall determine and propose for the Employer approval, thetype, size, weight and manner of installation for each location.Selection of equipment sub-racks and cabinets (enclosures) shall meet the following requirements:

(A) Equipment Sub Rack Construction

Equipment Sub Racks provided for installation in environmentally controlled facilities, shall meet the following minimum requirements:

(1) Equipment Sub Racks shall be steel/aluminium fabricated and finished on all surfaces. All metal and welds shall be thoroughly cleaned and sanded to obtain a smooth finish. All surfaces shall be treated for rust and primed to form a bond between metal and the finish coats of paint.

(2) Equipment covers shall be provided for exposed components mounted in equipment sub Racks.

(3) Dust and moisture protection shall meet or exceed IP20 standards.

(B) Equipment Cabinet (Enclosure) Construction

(1) Equipment cabinets (enclosures) shall be steel/ steel & Aluminium extrusion fabricated and finished on all surfaces. All metal and welds shall be thoroughly cleaned and sanded to obtain a smooth finish. All surfaces shall be treated for rust and primed to form a bond between metal and the finish coats of paint.
(2) Equipment cabinets (enclosures) shall be designed free-standing but shall be mounted to the floor. Cabinets (enclosures) shall have secure fitting, lockable, full-length front doors for access to hardware and wiring. Equipment covers for exposed components mounted inside cabinets are not required unless specifically recommended.
(3) All doors and removable panels shall be fitted with long life rubber beading. All panels shall be fabricated from minimum 2.0mm thickness steel sheet. However, for racks with load bearing Aluminium extrusion frame, door panels and side panels may be fabricated from minimum 1.6mm thickness steel sheet and the top & bottom panels shall be fabricated from minimum 2.0mm thickness steel sheet.
(4) Equipment cabinets (enclosures) shall be dust and moisture-proof as per IP41 specification, or better.

29.24.2 Cable Raceways

The Contractor is required to provide and install all additional necessary indoor and outdoor cable raceways. The cable raceways shall be in conformance with the following:

(1) Signal cabling and power cabling shall require separate cable raceways. Signal and power cabling shall not share the same raceways and shall be installed as far apart as is practical. Adequate shielding shall be provided as required.
(2) All cable raceways shall be sized to support full loading requirements plus at least a 200% safety loading factor.
(3) Outdoor cable raceways shall be of corrugated construction and shall be fitted with solid covers overlapping all sides of the cable raceways.
(4) Outdoor cable raceways shall be fabricated from construction grade aluminium, galvanized iron or anodized sheet metal or any other suitable material approved by the Employer. Suitable anti-corrosion measures shall be taken. Steel fabricated raceways shall be finished inside and out, treated to resist rust and to form a metal-to-paint bond.
(5) Indoor cable raceways fabricated of aluminium or galvanized iron, shall not normally need special finishing or painting, unless otherwise stipulated by the Employer. Steel fabricated raceways shall require a red oxide primer coat at a minimum.

29.24.3 Signalling Distribution

The Contractor shall be responsible for all signal wiring associated with furnished equipment in accordance with the following:
(1) All signal wiring connections to the communications equipment shall be via Krone type or equivalent terminal blocks.
(2) The Contractor shall provide subscriber level wiring and patching wherever required.

29.24.4 Lightning and Transient Voltage Protection

The Contractor shall be required to provide protection from lightning and transient voltages for all wideband communications equipment, in accordance with the following:
(1) At the outside cable plant point-of-entry of all cabling penetrations for all cabling installed by the Contractor, the Contractor shall provide lightning and transient voltage isolation for the inside plants cabling, wiring, and all terminations and equipment.

(2) All equipment installed under this specification that requires 240VAC primary power, shall be surge protected.

29.24.5 Station Safety Earthing and Signal Grounding

For each facility, the Contractor is responsible for meeting the following station and equipment earthing requirements:

(1) All safety earthing and signal grounding shall be in full compliance with EMI/EMC requirements as per relevant international standards.

(2) Each cabinet (enclosure) or cabinet (enclosure) group shall include suitable signal ground and safety earth networks. The signal ground network shall terminate at a separate signal ground stud connection isolated from safety earth.

(3) Each earth/ground network shall utilize copper bus bars, copper braids and/or 16 sq mm or bigger earth cable. All equipment earth/ground connections shall be made directly to the equipment chassis

utilizing grounding lugs and secured metal-to-metal with star washers. Use of the enclosure frame, skin or chassis mounting hardware as part of the earthing/grounding networks, is not acceptable.

(4) The safety earth network shall be connected to "earth ground" at the safety earth stud. The earth stud connection shall be sized for an external earthing cable equipped with a 2/0 solid copper lug secured metal-to-metal with star washers. Primary AC feeds and distribution within enclosures requires earthing wire connection to the safety earth stud.

(5) The safety earth and signal ground networks shall be inter-connected only at the safety earth stud and signal ground stud.

The Contractor shall extend the existing station earth to the equipment room using suitable G.I. earthing strip (50 x 6 mm), wherever required.

The Contractor is responsible for providing all required earthing/grounding cable and installation. Cabinet (Enclosure) and equipment safety earthing and signal grounding shall be subject to the Employer’s approval.

The Contractor shall be responsible for determining the suitability of existing station earth for the equipment to be supplied under this contract. In case existing earthing arrangement at the site is not adequate, the Contractor shall either make improvement in the existing earthing arrangement or make new earthing as per requirement.

29.25.0 Interconnections

All power and signal cabling between component units of the communications systems shall be supplied and installed by the Contractor and shall be shown on contractor supplied as-built drawings.

The Contractor shall supply and install all primary power cords, power-strips, receptacles, circuit breakers, fuse panels, switches, earth fault detectors, surge protectors, distribution cabling, and power connectors required to support all equipment enclosures and system components furnished and installed under this specification, except as specifically excluded.

Plug-type power connectors with captive fastening (such as "Twist-Lock") shall be used for interconnection of source power to the equipment enclosures or racks.

Plug-type connectors with captive fasteners (ie. DB-25, etc) shall be used for the interconnection of all inter and intra-enclosure signalling cable.

29.26.0 Finish Colors

Unless otherwise specified, finish colors for enclosures shall be gloss white enamel on the inside, and semi-gloss medium grey enamel on the outside. Only brushed aluminum trim shall be used. Employer reserves the right to approve the proposed color scheme.

29.27.0 Location of Equipment, Cable Routes and Associated Civil Works

During the Site Surveys, the Contractor shall determine and propose locations for all equipment to be supplied under this contract. Further, the Contractor shall locate and identify proposed routing for all cabling between all equipment locations including existing and planned equipment not provided under this contract, but required to be connected under the scope of this contract. This subsection defines the requirements and clarifies the responsibilities of the Employer and the Contractor regarding equipment

siting, intra and inter facility interconnectivity and necessary associated civil works.

29.27.1 Locations for Supplied Equipment

All transmission equipment and associated DDFs, shall generally be co-located in the same communications room located in the Control Building whenever possible.

29.29 Inspection, Test and Availability

i) All materials furnished and all work performed under this Contract shall be inspected and tested. Deliverables shall not be shipped until all required inspections and tests have been completed, and all deficiencies have been corrected to comply with this Specification and approved for shipment by the Employer.

ii) Except where otherwise specified, the Contractor shall provide all manpower and materials for tests, including testing facilities, logistics, power and instrumentation, and replacement of damaged parts. The costs shall be borne by the Contractor and shall be deemed to be included in the contract price.

iii) The entire cost of testing for factory & site acceptance, routine tests, production tests and other test during manufacture & site activities specified herein shall be treated as included in the quoted unit price of materials, except for the expenses of Inspector/Employer's representative.

iv) Acceptance or waiver of tests shall not relieve the Contractor from the responsibility to furnish material in accordance with the specifications.

v) All tests shall be witnessed by the Employer and/or its authorized representative (hereinafter referred to as the Employer) unless the Employer authorizes testing to proceed without witness. The Employer representative shall sign the test form indicating approval of successful tests.

vi) Should any inspections or tests indicate that specific item does not meet Specification requirements, the appropriate items shall be replaced, upgraded, or added by the Contractor as necessary to correct the noted deficiencies at no cost to the Employer. After correction of a deficiency, all necessary retests shall be performed to verify the effectiveness of the corrective action.

vii) The Employer reserves the right to require the Contractor to perform, at the Employer's expense, any other reasonable test(s) at the Contractor's premises, on site, or elsewhere in addition to the specified Type, Acceptance, Routine, or Manufacturing tests to assure the Employer of specification compliance. All security related features shall be demonstrated during FAT/SAT as required by the Employer.

29.29.1 Inspection

Access to the Contractor's facilities during system manufacturing and testing and to any facility where systems/ equipment are being produced/ tested/ integrated for the fibre optic communication network, shall be available to the Employer. At all times the Employer shall have full facilities for unrestricted inspection of such materials or equipment. To facilitate this, the Contractor shall submit for the Employer approval, a comprehensive Quality Assurance Plan using ISO 9000 as a general guideline. In addition, the Quality Assurance Plan shall satisfy the following:

(a) Sufficient office facilities, equipment, and documentation necessary to complete all inspections and to verify that the equipment is being fabricated and maintained in accordance with the Specification shall be provided by the Contractor to the Employer.

(b) Inspections to be performed by the Employer will include visual examination of hardware, cable dressings and labeling. Contractor's documentation will also be examined to verify that it adequately identifies and describes all offered items and spare parts.

(c) Access to inspect the Contractor's standards, procedures, and records that are applicable to the supplied equipment shall be provided to the Employer. Documents will be inspected to verify that the Contractor has performed the required quality assurance activities.

(d) The inspection rights described above shall also apply to sub Contractors who are responsible for supplying major components described in this Specification. These items shall be inspected and tested at the sub Contractor's factory by the Employer's representatives prior to shipping this equipment to the Contractor's facility or directly to the Employer.

(e) The above inspection rights shall also apply to sub Contractors supplying assemblies, subassemblies and components. However, such items will normally be inspected and tested by the Employer's representatives at the Contractor's site before acceptance.

29.29.2 Test Plans and Procedures

a) 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.

b) 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

c) 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.

d) 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.

29.29.3 Factory and Site Test Plans

A test plan for factory and site acceptance tests shall be submitted for approval, at least four (4) weeks before the start of testing. The test plan shall be a single overview document that defines the overall schedule and individual responsibilities associated with conducting the tests, documenting the test results,
and successfully completing the test criteria. Test Plans shall include, at a minimum, the information contained in Table 4-1.

Table 4-1
Factory & field Test Plan Requirements

Items	Description
1	Test Schedule
2	Record-keeping assignments, procedures and forms
3	Procedures for monitoring, correcting and retesting variances
4	Procedure for controlling and documenting all changes made to the communications equipment after the start of testing.

29.29.4 Test Procedures

Test procedures for factory and site testing shall be submitted for the Employer approval at least four (4) weeks before each individual test. Fully approved test procedures shall be submitted to the Employer at least four weeks prior to the commencement of testing. Testing shall not commence without approved test procedures. At a minimum, test procedures shall include the items listed in Table 4-2.

All test equipment and/or instruments shall bear calibration stickers indicating valid calibration on and beyond the testing date. The time lapsed since last calibration shall not exceed the test equipment/ jig manufacturer recommended calibration interval or the interval recommended in the test lab's internal quality procedures.

The Contractor shall ensure that all testing will be performed by qualified testing personnel well experienced in performing such tests.

Table 4-2
Test Procedure Requirements

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.

29.29.5 Test Records

Complete and indexed records of all factory and site acceptance tests results shall be maintained and provided to the Employer by the Contractor in hardcopy. The records shall be keyed to the steps enumerated in the test procedures. The minimal items required in test records are described in Table 4-3.

Table 4-3
Test Record Requirements

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.

29.29.6 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.

29.30.0 Type Testing

"Type Tests" shall be defined as those tests which are to be carried out to prove the design, process of manufacture and general conformity of the materials to this Specification. Type Testing shall comply with the following:

(a) All equipment being supplied shall conform to type tests as per technical specification.

(b) The test reports submitted shall be of the tests conducted within last five (5) years prior to the date of bid opening. In case the test reports are older than five years (5) ago on the date of bid opening, the Contractor shall repeat these tests at no extra cost to the purchaser.

(c) The Contractor shall submit, within 30 days of Contract Award, copies of test reports for all of the Type Tests that are specified in the specifications and that have previously (before Contract award) been performed. These reports may be accepted by the Employer only if they apply to materials and equipment that are essentially identical to those due to be delivered under the Contract and only if test procedures and parameter values are identical to those specified in this specifications carried out at accredited labs and witnessed by third party / customer's representatives. In the event of any discrepancy in the test reports or any type tests not carried out, same shall be carried out by Contractor without any additional cost implication to the Employer.

(d) Type Tests shall be certified or performed by reputed laboratories using material and equipment data sheets and test procedures that have been approved by the Employer. The test procedures shall be formatted as defined in the technical specifications and shall include a complete list of the applicable reference standards and submitted for Employer approval at least four (4) weeks before commencement of test(s). The Contractor shall provide the Employer at least 30 days written notice of the planned commencement of each type test.

(e) The Contractor shall provide a detailed schedule for performing all specified type tests. These tests shall be performed in the presence of a representative of the Employer.

(f) The Contractor shall ensure that all type tests can be completed within the time schedule offered in his Technical Proposal.

(g) In case of failure during any type test, the Supplier is either required to manufacture a fresh sample lot and repeat all type tests successfully or repeat that particular type test(s) at least three times successfully on the samples selected from the already manufactured lot at his own expenses. In case a fresh lot is manufactured for testing then the lot already manufactured shall be rejected.

29.30.1 Type Test Samples

The Contractor shall supply equipment/material for sample selection only after the Quality Assurance Plan has been approved by the Employer. The sample material shall be manufactured strictly in accordance with the approved Quality Assurance Plan. The Contractor shall submit for Employer approval, the type test sample selection procedure. The selection process for conducting the type tests shall ensure that samples are selected a random. At least three samples of each of the proposed equipment shall be offered for selection, out of which one sample for each equipment shall be selected.

29.30.2 List of Type Tests

The type testing shall be conducted on the following equipment

(a) SDH Equipment with all types of cards (optical card, Tributary card or any other equipment as part of repeater less links)

29.30.2.1 List of type test to be conducted on Telecom equipment

The type tests for SDH Equipment with all types of cards, Primary Multiplexer & Drop-Insert Mux with subscriber interface card and DACS are described below:

29.30.2.1.1 Temperature and Humidity Tests

The tests listed below are defined in IEC Publication 60068.

(a) Low Temperature Test: Operation to Specifications

Low temperature tests shall be conducted as defined in IEC Publication 60068-2-1, test method Ad, with the following specifications:

(1) Test Duration: The equipment is started up as soon as thermal equilibrium has been reached and operated for sixteen (16) hours. Its performance is checked during the test.

(2) Degree of Severity: Test shall be done at 0°C

(3) Acceptance Criteria: No degradation of performance during and after the test.

(b) Low Temperature Test : Operation without Damage

Low temperature tests shall be conducted as defined in IEC Publication 60068-2-1, test method Ad, with the following specifications:

(1) Test Duration: The equipment is started up as soon as thermal equilibrium has been reached and operated for 72 hours. Its performance is checked during the test and after the test as soon as the thermal equilibrium is reached at the room temperature (*Post-test*)

(2) Degree of Severity: Test shall be done at -10° C

(3) Acceptance Criteria: Degradation of performance is allowable during the however there shall be no degradation of performance in the *post-test*.

(c) Dry Heat Test: Operation to Specifications

Dry heat test shall be done as defined in IEC Publication 60068-2-2, test method Bd, with the following specifications:

(1) Test Duration: The equipment is started up as soon as thermal equilibrium has been reached and operated for 96 hours.

(2) Degree of Severity: As per table 5-1: operation to specification range.

(3) Acceptance Criteria: No degradation of performance during and after the test.

(d) Dry Heat Test: Operation without Damage

Dry heat tests shall be done as defined in IEC Publication 60068-2-2, test method Bd, with the following specifications:

(1) Test Duration: The equipment is started up as soon as thermal equilibrium has been reached and operated for 96 hours. Its performance is checked during the test and after the test as soon as the thermal equilibrium is reached at the room temperature (*Post-test*).

(2) Degree of Severity: Test shall be done at 55ºC.

(3) Acceptance Criteria: Degradation of performance is allowable during the however there shall be no degradation of performance in the *post-test*.

(e) Damp Heat Test

Damp heat testing reveals aging with respect to the humidity level and applies basically to electronic equipment. This test shall be done as defined in IEC Publication 60068-2-3 with the following specifications

(1) Test Duration: The equipment is started up as soon as thermal equilibrium has been reached and operated for 10 days. Its performance is checked during the test.

(2) Acceptance Criteria: The equipment shall meet the specified requirement and there shall not be any degradation in BER.

(f)Temperature Variation Test

Temperature variation testing shall be as per IEC Publication 60068-2-14 (Gradual Variations, Method Nb). The equipment shall be powered on and various parameters shall be monitored continuously during the test period.

(1) Number of cycles required is five (5)
(2) The degree of severity: temperature TL:0°C, TH: As per table 5-1 (Operation to specification range)
(3) Cycle duration for each temperature is three (3) hours.
(4) Ramp : 1 oC/minute.
(5) Acceptance Criteria: The equipment shall meet the specified requirement and
there shall not be any degradation in BER.

29.30.2.2 Power Supply and EMI/EMC tests

The test procedure and acceptance criteria shall be as defined in IEC 60870-2-1.
Immunity Tests
The list of Immunity tests are specified below in Table 4-4:

Table 4-4: Recommended Immunity Tests

Sl No	Immunity Test	AC Power Supply	DC Power Supply	Control & Signal	Telecom Line	Parametres
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	

Sl No	Immunity Test	AC Power Supply	DC Power Supply	Control & Signal	Telecom Line	Parametres
3	100/1300 µs surge	Yes	Yes	N/A	N/A	Table 12 of IEC 60870-2-1: 1995
4	1.2/50 - 8/20 µs surges	Yes	Yes	N/A	N/A	Table 12 of IEC 60870-2-1: 1995 - **Level : 4**
5	Fast transient bursts	Yes	Yes	Yes	N/A	
6	Damped oscillatory waves	Yes	Yes	Yes	Yes	
7	10/700 µs surges	**N/A**	**N/A**	**N/A**	**Yes**	
8	Electrostatic discharge	**Yes**				Table 13 of IEC 60870-2-1: 1995 - **Level : 4**
9	Power frequency magnetic field	**Yes**				Table 14 of IEC 60870-2-1: 1995 - **Level : 4**
10	Damped oscillatory magnetic field	**Yes**				
11	Radiated electromagnetic field	**Yes**				Table 15 of IEC 60870-2-1: 1995 - **Level : 4**
12	Power Frequency voltage on control and signal lines	**N/A**	**N/A**	**Yes**	**Yes**	IEC 61000-4-16 : 2002-07 **Level : 4**
13	DC voltage on control and signal lines	**N/A**	**N/A**	**Yes**	**N/A**	IEC 61000-4-16 : 2002-07 **Level : 4**

(a) **Emission Tests:**

The list of Emission tests are specified below in Table 4-5

Table 4-5:
Recommended Emission Tests

S. NO.	Emission test	AC Power Supply	DC Power Supply	Control & Signal	Telecom Line	Parametres
1	LF disturbance voltages CCITT	N/A	Yes	N/A	N/A	Table 17 of IEC

	Recommendation P.53					60870-2-1: 1995 - Class **: B**
2	Transient disturbance voltages	Yes	Yes	N/A	N/A	
3	RF disturbance voltages CISPR 22	Yes	Yes	N/A	N/A	
4	RF disturbance currents CISPR 22	N/A	N/A	N/A	Yes	
5	RF radiated fields CISPR 22	**Yes**				

(c) Insulation Withstand Voltages

As per section 6 of IEC 870-2-1. Recommended class : VW1 of Table 18.

29.30.2.3 Mechanical Tests

(a) Mechanical Vibration Test

The procedure for this test is described in IEC Publication 60068-2-6. The testing procedure shall be carried out in the sequence 8.1 + 8.2.1 + 8.1 as described in document 60068-2-6.

For the vibration response investigation (clause 8.1 of 60068-2-6), the test shall be carried out over a sweep cycle under the same conditions as for the endurance test (described later), but the vibration amplitude and the sweep rate may be decreased below these conditions so that the determination of the response characteristics can be obtained.

The endurance test conditions are selected according to the vibration withstand requirements. Transportation tests shall be performed with the equipment packed according to the Contractor's specifications.

Shock Test

The procedure of this test is defined in IEC Publication 60068-2-27 (each test) with a semisinusoidal shape (clause 3.1.1.2).

The recommended severity shall be A = 294 m/s^2, D = 18 ms. Three shocks per axis per direction shall be applied to the equipment packed according to the Contractor's specifications.

Or Free Fall Test

This test could be performed as an alternative to the shock or Bump test. The procedure is defined in IEC publication 60068-2-32. The equipment shall be packed according to the Contractor's specifications. The drop height shall be defined in accordance with IEC 68-2-32. The surface of the packing case which comes into contact with the ground is the surface on which the packing case normally rests; if the packing does not have any features (inscription, special shape, etc.) identifying this surface, the test is carried out successively on all the surfaces of the packing.

Or Bump Test

This test could be performed as an alternative to Shock test or Free Fall test. The procedure is defined in IEC 60068-2-29.

29.30.2.4 Factory Acceptance Tests

Factory acceptance tests shall be conducted on randomly selected final assemblies of all equipment to be supplied. Factory acceptance testing shall be carried out on

SDH Equipments, associated line & tributary cards, Termination Equipments (Primary Mux, Drop/Insert, DACS, associated Subscriber Line Interface Cards etc), Network Management System etc. and all other items for which price has been identified separately in the Bid Price Schedules.

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

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

The factory acceptance test shall demonstrate the technical characteristics of the equipment in relation to this specifications and approved drawings and documents. List of factory acceptance tests for Fibre Optic Transmission system, Termination Equipment Sub-system and NMS are given in specified Tables in this section. This list of factory acceptance tests shall be supplemented by the Contractor's standard FAT testing program. The factory acceptance tests for the other items shall be proposed by the Contractor in accordance with technical specifications and Contractor's (including Sub-Contractor's / supplier's) standard FAT testing program. In general the FAT for other items shall include at least: Physical verification, demonstration of technical characteristics, various operational modes, functional interfaces, alarms and diagnostics etc.

For Test equipment & clock, FAT shall include supply of proper calibration certificates, demonstration of satisfactory performance, evidence of correct equipment configuration and manufacturer's final inspection certificate/ report.

29.30.2.5 Sampling for FAT

From each batch of equipment presented by the Contractor for Factory acceptance testing, the Employer shall select random sample(s) to be tested for acceptance. Unless otherwise agreed, all required FAT tests in the approved FAT procedures, shall be performed on all samples. The Sampling rate for the Factory acceptance tests shall be minimum 10% of the batch size (minimum 1) for all items. The physical verification shall be carried out on 100% of the offered quantities as per the approved FAT procedure. In case any of the selected samples fail, the failed sample is rejected and additional 20% samples shall be selected randomly and tested. In case any sample from the additional 20% also fails the entire batch may be rejected. In case a number of equipments are required for demonstration of the performance of any equipment during FAT, the sample size shall be taken as that number of equipments which are necessary to demonstrate the performance, irrespective of the percentage.

Since FAT testing provides a measure of assurance that the Quality Control objectives are being met during all phases of production, the Employer reserves the right to require the Contractor to investigate and report on the cause of FAT failures and to suspend further testing/ approvals until such a report is made and remedial actions taken, as applicable.

29.30.2.6 Production Testing

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

Table 4-6:
Factory Acceptance Testing for Fibre Optic Transmission System

Item	Description
1	Physical inspection for conformance to DRS, BOQ, drawings and appearance of equipment
2	Optical output power
3	Transmitter lightwave spectral analysis
4	Low receive level threshold
5	Generation of bit error rate curve
6	Measurement of analog and digital service channel parameters as well as service channel functionality
7	Performance of supervision, alarm, Craftsperson interface, diagnostics, loop backs etc.
8	Electrical interface tests which include: output and input jitter, bit error rate, pulse shape, cable compensation, and line rate tolerance for multiplexers
9	At a minimum tests on Ethernet interface shall include demonstration of ping test, throughput test, Latency test, Packet Loss test as per RFC 2544
10	Simulation of failure conditions and failover of each redundant unit.
11	Test of spare card slots
12	Checks of power supply/converter voltage margins
13	Random inspections to verify the accuracy of documentation
14	Test of spare parts/modules/cards as per applicable tests

2.30.2.7 Site Acceptance Tests

The Contractor shall be responsible for the submission of all equipment & test equipment supplied in this contract for site tests and inspection as required by the Employer. All equipment shall be tested on site
under the conditions in which it will normally operate. The tests shall be exhaustive and shall demonstrate that the overall performance of the contract works satisfies every requirement specified. At a minimum Site Acceptance Testing requirement for Telecom equipment, NMS etc. is outlined in following section. This testing shall be supplemented by the Contractor's standard installation testing program, which shall be in accordance with his quality plan(s) for Telecom equipment installation.

During the course of installation, the Employer shall have full access for inspection and verification of the progress of the work and for checking workmanship and accuracy, as may be required. On completion of the work prior to commissioning, all equipment shall be tested to the satisfaction of the Employer to demonstrate that it is entirely suitable for commercial operation.

29.30.2.8 Phases for Site Acceptance Testing

The SAT shall be completed in following phases:

29.30.2.9 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 and NMS are provided in respective Tables in this section.

29.30.2.10 Link Commissioning Tests

The commissioning tests shall verify that communication can be performed over the fiber optic link under test. Delay measurement, Bit Error measurements & service channel performance monitoring shall be made on the fibre optic links to verify compliance with designed link performance.

For Ethernet interface: At a minimum the following test requirements shall be demonstrated

as per RFC 2544:

a) Ping test

b) Throughput test

c) Latency test

d) Packet Loss

10% of the total links (Chosen by the Employer, generally to cover links from all configurations used)

shall be tested for a duration of 12 Hours. Rest of the links shall be tested for 1 Hour. In case a link does not meet the performance requirements during 1 hour, then the duration of the test shall be increased to 12 hours.

In case any link does not meet the performance requirements during 12 hour, then the cause of failure shall be investigated and the test shall be repeated after rectifying the defects. This phase of testing shall be conducted by the Contractor and witnessed by the Employer. Field adjustments shall be made to meet established standard, however if the field adjustments fail to correct the defects the equipments may be returned to the Contractor for replacement at his own expense. In case any adjustments are required to be made during the interval of the test then the test shall be repeated.

29.30.2.11 Integrated Testing

Prior to commencement of integrated testing the overall system shall be configured as required to provide all the channels required to interconnect the various User's interfaces. The integrated testing for 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 backbone. 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, the network management subsystem and other components.

At a minimum the following tests shall be included in the integrated testing:

(1) Equipment configuration shall be checked to establish that it supports the channel routing.

(2) Testing of Craft Terminal to demonstrate proper operation of all functions: Configuration Management, Performance Management, Fault, Management and Security management. All the standard features of the Craft Terminal based NMS shall be demonstrated for proper functioning.

(3) Demonstration of Protection switching and synchronization of equipment as per synchronization plan.

Table 4-7

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.

29.31 Training and Support Services

This section describes the requirements for Contractor-supplied training, support services, and maintenance of the FOTS. The intent of the training and support program is to ensure a smooth transfer of systems and technologies from the Contractor to the Employer, and to ensure that Employer staff is fully trained to operate, maintain and expand the integrated telecommunication network.

29.31.1 Training

The Contractor shall provide a comprehensive training program that prepares the Employer’s personnel for on-site installation support, operation, and maintenance of the telecommunication network.

Training may be conducted by the Contractor, the Contractor's subcontractors, and/or original equipment manufacturers (OEMs). The training requirements of this Specification shall apply to all such courses.

Training courses shall be conducted by personnel who speak understandable English and who are experienced in instruction. All necessary training material shall be provided by the Contractor. The training charges quoted by the Contractor shall include training materials and all associated expenses. However, for all training courses in India or abroad, the travel (e.g., airfare) and per diem expenses covering fooding and Lodging of the participants will be borne by the Contractor. For courses conducted abroad, however, the Contractor shall extend all necessary assistance for making appropriate lodging arrangement.

Hands-on training shall be provided with equipment identical to that being supplied to the Employer. The schedule, location and detailed training contents shall be submitted by the Contractor to the Employer for approval.

29.31.2 System Design & Overview Training

This training shall provide a functional description of the fibre optic transmission system and a discussion of the failover and alternate routing schemes inherent in the configuration. The training shall include an overview of the network configuration and indicate the functional responsibilities of all major subsystems including the network monitoring system hardware and software. The training shall highlight all significant methodologies or concepts utilized by the hardware and software to perform the required functions. High-level hardware configuration block diagrams and network/sub-network block/flow diagrams shall be included to enhance the understanding of the overall capability incorporated into all network and sub-network equipment.

The training shall be oriented to a user's point of view. The Employer/Owner users will include managers, design & planning personnel, communication support staff and maintenance personnel. As part of the proposal, the Contractor shall identify the number of days deemed appropriate for this training.

The overview training shall be customized for the specific functions, features, and equipment purchased by the Employer; it shall not be a general presentation of the Contractor' standard equipment repertoire. Personnel assigned by the Contractor to implement the Employer's system shall conduct this overview training. The Employer shall review and approve the contents of the overview training at least four (4) weeks prior to the course.

29.31.3 Installation & Maintenance Training

There shall be separate modules of the installation & maintenance training for the FO Transmission System.

The installation & maintenance trainings shall enable the Employer to be self-sufficient in preventive &
restorative maintenance of the respective communications subsystems purchased by the Employer. **In addition to that the Bidder shall provide Video Tutorials or necessary documentation for maintenance and trouble shooting.**

29.31.4 Network Management Training

The Network Management training shall familiarize the Employer’s telecommunication personnel with the concepts and techniques for configuring, programming, maintaining, and troubleshooting the Contractor supplied NMS and its associated database. The Network Management training course shall provide the course participants with hands-on experience using the actual system being supplied.

29.31.5 Training Course Requirements

This section describes general requirements that apply to all training courses

29.31.5.1 Class Size

The Employer plans to send a number of participants to the training courses for a specified duration as described in Appendices.

29.31.5.2 Training Schedule

The Contractor shall provide training in a timely manner that is appropriate to the overall project schedule. All training courses shall be available to the Employer for a minimum of five years after final acceptance of the communication system. The training courses shall be offered in one cycle, such that none of the courses within the cycle overlap. The Contractor shall take the above requirements into account in developing the preliminary training schedule. Contractor shall develop a final training schedule in consultation with the Employer after contract award.

29.31.5.3 Manuals and Equipment

The Contractor, subcontractor, or OEM shall prepare training manuals and submit them to the Employer for review at least one month prior to the start of classroom instruction. The training manuals shall be prepared specifically for use as training aids; reference manuals, maintenance manuals, and user's manuals may be used as supplementary training material. Principal documents used for training shall be tailored to reflect all the Employer requirements specified.

Each course participant shall receive individual copies of training manuals and other pertinent material at least two weeks prior to the start of each course. The Employer shall retain the master and two additional copies of all training manuals and materials as reference documentation. A complete set of instructor's manuals and training aids shall also be provided. Upon completion of each course, instructor's manuals, training manuals, and training aids shall become the property of the Employer. As part of the delivered system documentation and the final documentation, the Contractor shall supply the Employer with all changes and revisions to the training manuals and other training documentation. The Employer reserves the right to copy all training manuals and aids for use in the Employer-conducted training courses. The Contractor shall furnish for use during training courses all special tools, equipment, training aids, and any other materials required to train course participants.

29.32 Support Services

Throughout design, implementation, factory testing, and field installation and testing, the Contractor shall supply consulting assistance, as required by the Employer for site preparation, field installation, and other areas where technical support may be required. The Contractor shall be responsible for minor facility renovation, and maintenance of the supplied system up to and including successful completion of the Site Acceptance Test. After final acceptance of the communications equipment, the Contractor shall offer continuing technical support and spare parts for the designed life of the equipment or 7 years after the declaration of withdrawal of equipment from production whichever is earlier. However the termination of production shall not occur prior to Operational Acceptance of the system by the Employer.

29.32.1 Technical Support

Consultation with Contractor's technical support personnel and trained field service personnel shall be readily available on a short-term/long-term basis to assist the Employer personnel in maintaining, expanding, and enhancing the telecommunication network upon expiration of the warranty period. The Contractor shall include in their offer(s), a proposal for ensuring continued technical support as stated above

29.32.2 Contractor's Future Hardware/Software Changes

The Employer shall be informed of all alterations or improvements to the hardware supplied under this Specification. The Employer shall be placed on the Contractor's mailing list to receive announcements of the discovery, documentation, and solution of hardware/software problems as well as other improvements that could be made to supply equipment. The service shall begin at the time of contract award, and shall continue for 10 years. The Contractor shall also include a subscription to the hardware subcontractors' change notification service from the time of contract award through the warranty period, with a Employer renewable option for extended periods.

29.32.3 Spare Parts and Test Equipment

The spare parts and test equipment shall be provided for each subsystem as described below.

29.33 Mandatory Spare Parts

Appendices provides the Mandatory Spare Parts Requirements described in **subsystem sets**. The mandatory spare parts table represents the minimum spares the Contractor shall be required to supply. The **subsystem set** of spare parts is defined to include all equipment modules, subunits and parts required to effect replacement, repair and restoration to full operational status of a defined unit of a subsystem.

29.33.1 Test Equipment

Appendix-B provides mandatory test equipment requirements, to be provided. The parameters / features of the mandatory equipments are enumerated in Table 6.2 below and shall be as per the Chapter “spares and tools”

Table 6.2

Sl. No.	**Test equipment**	
	SDH Analyser	
	Handheld 2Mbps BER Tester	
	Digital Multimeter	
	Ethernet Tester (with dual port, 10/100 ports Mbps Ethernet option, layer-1 & layer-2 functionality)	

In case the offered make/model of test equipment has multiple options for the parameters, the option of higher range shall be acceptable. The supplied test equipment shall be suitable for use in the high EMI/EMC environment. The Contractor shall submit performance certificate for offered test equipment from at least one customer.

The Contractor shall provide in their bid, additionally recommended test equipment list necessary to support system availability figures specified in technical specifications. These lists shall include all relevant technical descriptions and recommended minimum quantities based upon the guidelines consistent with the telecommunications resource management hierarchy and continuing maintenance concept. The recommended test equipment shall not be considered for evaluation and may be included in the final scope of supply.

29.34 System Maintenance

As per DoT guidelines, operation and maintenance of the network shall be entirely by Indian engineers and dependence on foreign engineers shall be minimal within a period of two years from the date of LoA. The contractor shall be responsible to maintain the confidentiality of the Employer's System Information that Employer shares with the contractor for maintenance period.

29.34.1 Warranty Period

The one year period commencing immediately after the operational acceptance is called the Warranty Period/Defect liability Period. In addition to the responsibilities covered under Vol I Condition of Contracts during Defect Liability Period, the Contractor shall also be responsible for maintenance of the Fibre Optic Transmission System supplied under this Package. The specification for the maintenance of the system after Operational Acceptance is enclosed at Annexure-I.

29.34.2 Contractor's Maintenance Responsibility

The Contractor shall be responsible for carrying out "Non-Comprehensive Maintenance" of the Communication System for a period of six years after warranty period for ensuring the successful operation of the system. The Contractor shall be responsible for achieving the system availability and the response time mentioned in technical specifications. The tenderer shall quote the Annual Maintenance Charges for six years after Warranty Period which shall be considered in the bid evaluation. Tenderer shall submit the detailed procedure for achieving above in the bid. The specification for the maintenance of the system is enclosed at Annexure-I. Upon expiry of the six years AMC period Employer may, at its discretion, extend this Maintenance for additional one year at the same price & terms and conditions.

29.34.3 Miscellaneous Supplies

The Contractor shall provide all required consumable and non-consumable supplies necessary to support all installation and test activities through final operational acceptance. However, if there are any problems in the SAT and additional consumables are required, the same shall also be supplied by the Contractor at no additional cost.

29.35 Documentation

The Contractor shall submit following documents during detailed engineering:

(a) Data Requirement sheets
(b) Link Budget calculations
(c) MQP, FQP
(d) Bill of Quantity including mandatory spares
(e) Previous Type test reports
(f) Factory Test report

(g) Manuals for each equipment
(h) Schematic drawing
(i) Numbering, Marking, labelling document
(j) Synchronization plan
(k) Test schedule
(l) Training manual
(m) Configuration diagram
(n) Transportation & handling Procedure
(o) Installation Manuals
(p) Maintenance Manual

APPENDIX-D

BILL OF QUANTITIES OF FIBRE OPTIC TERMINAL COMMUNICATION EQUIPMENT (REFER PRICE SCHEDULE FOR BOQ FIBRE OPTIC TERMINAL COMMUNICATION EQUIPMENT)

APPENDIX-E
(The following data shall be furnished for each of the manufacturer)
DRS Form 01
DATA REQUIREMENTS SHEETS for
OPTICAL LINE TERMINATION EQUIPMENT (OLTE)

GENERAL OLTE FEATURES

Sl No	Parameter:	As per Technical Specification	As per Tenderer Offering
1	SDH hierarchy level: Capacity Aggregate Bit-rate: CEPT E-1 Ports: SDH Heirarchy Level: STM-16	STM-16 620 Mbps 252 x E1	
2	Minimum No. of protected (MSP) directions	Five	
3	No. of E1 ports in E1 tributary Cards	minimum 63	
4	No. of ethernet ports in Ethernet interface tributary cards	minimum 8	
5	Service Channel provision a) Voice Channel b) Data Channel	Yes Minimum 8 Minimum 4	
6	Power Supply cards of SDH Equipment Common Control* Card of SDH equipment	1:1 APS 1:1 APS	

GUARANTEED TECHNICAL PARTICULARS FOR VALVE REGULATED LEAD ACID BATTERY

(To be filled in and signed by the Tenderer)

1	**Type/ Designation**	**48V, 200AH battery bank**
2	Manufacturer's type designation	
3	Ampere-Hour capacity 10hrs rate of discharge to 1.75V	
4	Total No. of Plates per cell	
5	Nominal Cell Voltage (V)	
6	No. of Cells in each Bank	
7	No. of Spare Cell, if any, in each Bank	
8	Internal Resistance for each Cell	
9	Resistance of the Battery including Inter-connection between the	
10	Cell Discharge rate in Ampere (from rated Voltage to final discharge rate in Ampere (i) 5hrs Discharge rate in Amp (ii) 2hrs Discharge rate in Amp (iii) 1hr Discharge rate in Amp (iv) 30min Discharge rate in Amp (v) 10min Discharge rate in Amp (vi) 1min Discharge rate in Amp (vii) 30sec Discharge rate in Amp (viii) 1sec Discharge rate in Amp (Please furnish a graph showing Amps against time for the type of battery offered)	
11	Short Circuit Current (Amps)	
12	(i) Material of Cell Containers (ii) Material used for Battery Box (iii) Trays	
13	Thickness, Type & Material of Separators	
14	Constructional details and dimension: Surface area plates of (i) Positive Plate (ii) Negative Plate in Sq.mm.	
15	(i) Ampere Hour efficiency (%) (ii) Watt Hour efficiency (%)	
16	(i) Recommended Float Charge Current & Voltage (ii) Recommended Boost Charge Current & Voltage	
17	Time required for Boost Charging from Discharged condition	
18	(i) Max. Charging Current/Cell (ii) Nominal Charging Rate	
19	(i) Whether explosion proof or vent plugs provided (ii) Whether vent is spill proof	
20	Type of Inter Cell connection & whether they are covered with plastic sleeves	
21	(i) Dimensions of each 2V Block/Cell a. Length (mm) b. Width (mm) c. Height (mm) (ii) Thickness of Container (mm)	

CHAPTER 30: TECHNICAL SPECIFICATION FOR SAMAST METER

Interface Energy Meters Technical Specification

30.1 Basic Features of Interface Energy Meters

(a) The energy metering system specified herein shall be used for tariff metering for bulk, inter-utility power flows, in different States of India. Static composite meter shall be installed at interface points as a self-contained device for measurement of Voltage (V), Frequency (f), Active (Wh) and Reactive (VArh) energy exchanged in each successive 5 min time block. All meters shall be compliant to IS 15959 and its latest amendments.

(b) Each meter shall have a unique identification code, which shall be marked permanently on its front, as well as in its memory. All meters supplied to as per this specification shall have their identification code starting with “IEM”, which shall not be used for any other supplies. “IEM” shall be an eight digit running serial number, further followed by “A” and “B” for the use with CT secondary of 1A and 5A respectively. This shall be mutually agreed between the buyer and the vendor. Note: The secondaries of all the CT cores will be 1A.

(c) The meters shall be suitable for communication with external device like modem, DCU, etc. which shall be able to communicate with CDCS for local/remote data transfer. The meter shall compulsorily have at least 1 optical port for taking reading through Hand Held Unit (HHU).

(d) Auxiliary Supply to IEM- The meters shall normally operate with the power drawn from DC auxiliary power supply (Range 110V to 220V DC)to reduce the Voltage Transformer (VT) burden. In addition, there shall be provision to operate the meter from the Voltage Transformer (VT) secondary circuit having a rated secondary line-to-line voltage of 110V, and current transformers (CTs) having a rated secondary current of 1 A or 5A. Any further transformers/ transactions/ transducers required for their functioning shall be in-built in the meters. Necessary isolation and/or suppression shall also be built-in, for protecting the meters from surges and voltage spikes that occur in the VT and CT circuits of extra high voltage switchyards. The reference frequency shall be 50Hz. Also, the meter shall have suitable tolerance (up to 15% either side) for DC supply.

(e) The meters shall safely withstand the usual fluctuations arising during faults etc. In particular, VT secondary voltages 115% of Vref applied continuously and 190% of Vref for 3.0 seconds, and CT secondary current 150% of Iref applied continuously and 30 times of Iref applied for 0.5 seconds shall not cause any damage to or maloperation of the meters.

(f) The meters shall continue to function for the remaining healthy phase(s), in case one or two phases of VT supply fails. In case of a complete VT supply failure, the computation of average frequency shall be done only for the period during which the VT supply was available in the 5-minute block. Any time block contraction or elongation for clock correction shall also be duly accounted for.

(g) The total burden imposed by a meter for measurement and operation shall be defined as per IS 14697. An automatic backup for continued operation of the meter’s calendar-clock, and for retaining all data stored in its memory, shall be provided through a long-life battery, which shall be capable of supplying the required power for at least 2 years. The meters shall be supplied duly fitted with the batteries, which shall not require to be changed for at least 10 years, as long as total VT supply interruption does not exceed two years. The battery mounting shall be designed to facilitate easy battery replacement without affecting PCB of the meter.

(h) The meters shall fully comply with all stipulations in IS 14697 except those specifically modified by this specification. The reference ambient temperature shall be 27 ℃.

(i) Each meter shall have a test output device (visual), as per clause 6.11 of IS 14697.1999, for checking the accuracy of active energy (Wh) measurement. The preferred pulsing rate is twenty (20) per Wh for CT sec-1A and four (4) per Wh for CT sec –5A. It shall be possible to couple this device to suitable testing equipment also.

(j) **Exception Management**- The three line-to-neutral voltage shall be continuously monitored and in case any of these falls below defined threshold (70% of Vref), meter shall have suitable indication on LED/ LCD. The meter shall also have provision for low voltage event logging in meter memory in case of any phase voltage going below a defined threshold. The time blocks in which such a voltage failure occurs/persists shall also be recorded in the meter's memory with a symbol"*" if 3 Phase RMS voltage applied to the IEM is in between 5% to 70% of Vref and if Voltage is less than 5% of Vref, meter should record Zero voltage symbol "Z".

(k) **Time Accuracy** - Each meter shall have a built-in calendar and clock, having an accuracy of 10 seconds per month or better. The calendar and clock shall be correctly set at the manufacturer's works. The date (year-month-day) and time (hour-min.-sec.) shall be displayed on the meter front on demand. Meter shall have the intelligence to synchronize the time with GPS (Local GPS/CDCS GPS/ NAVIC) signal and from PC using software. Limited time synchronization through meter communication port shall be possible at site. When an advance or retard command is given, twelve subsequent time blocks shall be contracted or elongated by five seconds each. All clock corrections shall be registered in the meter's memory and suitably shown on print out of collected data.

(l) A touch key or push button shall be provided on the meter front for switching on the display and for changing from one indication to the next. The display shall switch off automatically about one minute after the last operation of touch key/push button. When the display is switched on, the parameter last displayed shall be displayed again, duly updated.

(m) The whole system shall be such as to provide a print out (both from the local PC, and from remote central computer) of the following format:

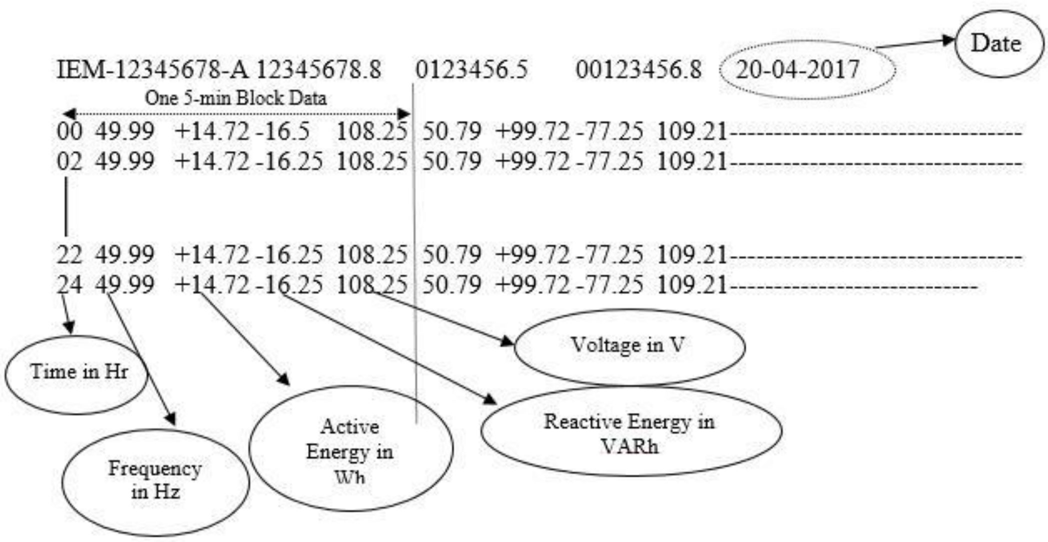

Figure 1: **Standard Raw Data Format for IEM**

There are 4 values in one 5 min time block. The first row shall contain the meter data for 2 hours, i.e. 24 time blocks, 00 hrs to 02:00 hrs. Similarly the 2^{nd} row shall contain the data for the next 2 hours and henceforth.

The above data shall be available in text file format (file extension as per IEEE standard/.txt) exportable to Excel. Indication of time retard or advance to be provided without disturbing the proposed format. Each 5-min block data consists of Frequency (in HZ), Active energy (in Wh), Reactive energy (in VARh) and Voltage (in V). All 5 minute Wh and VARh figures in .NPC/output report shall be rounded off upto third decimal.

(n) The portable hand held unit (HHU)/ Common meter reading instrument (CMRI)/ Data Collecting Device (DCD) shall be having IS-15959:2011 compatibility for standardized parameters. The optical coupler for tapping data stored in the SEMs memory shall be compatible universally across different make of SEMs.

30.2 Constructional Features

30.2.1 The meters shall be supplied housed in compact and sturdy, metallic or moulded cases of non-rusting construction and/or finish. The cases shall be designed for simple mounting on a plane, vertical surface such as a control/relay panel front. All terminals for CT and VT connections shall be arranged in a row along the meter's lower side. Terminals shall have a suitable construction with barriers and cover, to provide a secure and safe connection of CTs and VTs leads through stranded copper conductors of 2.5 sq. mm. size.

30.2.2 All meters of the same model shall be totally identical in all respects except for their unique identification codes. They shall also be properly sealed and tamper evident, with no possibility of any adjustment at site, except for transactions allowed in IS 15959.

30.2.3 The meters shall safely withstand, without any damage or mal operation, reasonable mechanical shocks, earthquake forces, ambient temperature variations, relative humidity etc. in accordance with IS-14697. They shall have an IP-51 category dust-tight construction, and shall be capable of satisfactory operation in an indoor, non-air conditioned installation.

30.2.4 Either the meters shall have built-in facility (e.g. test links in their terminals) for in-situ testing, or a separate test block shall be provided for each meter.

30.3 Measurement

30.3.1 The active energy (Wh) measurement shall be carried out on 3-phase, 4-wire principle, with an accuracy as per class 0.2S (IS 14697).

30.3.2 The meter shall compute the net active energy (Wh) sent out from the substation bus bars during each successive 5 min block, and store it in its memory up to fourth decimal with plus sign if there is net Wh export and with a minus sign if there is net Wh import. Further Wh data in .NPC/output report shall be rounded upto third decimal.

30.3.3 The meter shall count the number of cycles in VT output during each successive 5 min block, and divide the same by 300 (60 sec/min x 5min) to arrive at the average frequency. The frequency data shall be stored in the meter's memory in Hertz up to third decimal. Further Frequency data in .NPC/output report shall be rounded off upto second decimal.

30.3.4 The meter shall continuously compute the average of the RMS values of the three line-to-neutral VT secondary voltages as a percentage of 63.51 V, and display the same on demand. The accuracy of the voltage measurement/computation shall be at least 0.5%, a better accuracy such as 0.2% in the 95-105% range being desirable. The voltage data shall be stored in the meter's memory in volts up to third decimal. Further voltage data in .NPC/output report shall be rounded off upto second decimal.

30.3.5 The Reactive energy (VARh) measurement shall be carried out on 3-phase, 4-wire principle, with an accuracy of 0.5S as specified in IS 14697. The meter shall compute the net Reactive energy (VARh) sent out from the substation bus bars during each successive 5 min block, and store it in its memory up to fourth decimal with plus sign if there is net VARh export and with a minus sign if there is net VARh import. It shall also display on demand the net VARh sent out during the previous 5 min block. Further VARh data in .NPC/output report shall be rounded off upto third decimal.

30.3.6 The meter shall also integrate the reactive energy (VARh) algebraically into two separate registers, one for the period for which the average RMS voltage is above 103.0%, and the other for the period for which the average RMS voltage is below 97.0 %. The current reactive power (VAR), with a minus sign if negative, and cumulative reactive energy (VARh) readings of the two registers (>103% and <97%) shall be displayed on demand. The readings of the two registers at each midnight shall also be stored in the meter's memory. When reactive power is being sent out from substation bus bars, VAR display shall have a plus sign or no sign and VARh registers shall move forward. When reactive power flow is in the reverse direction, VAR display shall have negative sign and VARh registers shall move backwards. Generally, the standard PT ratios are 33kV/110V, 132kV/110V, 220 kV /110 V, 400 kV /110 V and 765 kV / 110 V. However, at the time of commissioning the vendor may confirm the same from site and configure the meter accordingly to ensure correct recording of reactive energy.

30.3.7 For CT secondary rating of 5A, all computations, displays and memory storage shall be similar except that all figures shall be one fifth of the actual, worked out from CT and VT secondary quantities.

30.3.8 Further, the meter shall continuously integrate and display on demand the net cumulative active energy sent out from the substation bus bars up to that time. The cumulative Wh reading at each midnight shall be stored in the meter's memory. The register shall move backwards when active power flows back to substation bus bars.

30.3.9 Errors for different power factors shall be as defined in IS14697.
30.3.10 For reactive power (VAR) and reactive energy (VARh) measurements, IS14697 shall be complied with. The accuracy of measurement of reactive energy shall be as per class 0.5S.
30.3.11 The harmonics shall be filtered out while measuring Wh, V and VARh, and only fundamental frequency quantities shall be measured/computed.
30.3.12 Data security shall be ensured as per IS 15959 (three layers of security).

30.4 Memory/ Storage

30.4.1 Each meter shall have a non-volatile memory in which the following shall be automatically stored:
30.4.2 Average frequency for each successive 5 min block, in Hertz up to third decimals.
30.4.3 Net Wh transmittal during each successive 5 min block, up to fourth decimal, with plus sign if there is net Wh export and with a minus sign if there is net Wh import.
30.4.4 Net VARh transmittal during each successive 5 min block, up to fourth decimal, with plus sign if there is net VARh export and with a minus sign if there is net MVARh import.
30.4.5 Cumulative Wh transmittal at each midnight, in eight digits including one decimal.
30.4.6 Cumulative VARh transmittal for voltage high condition, at each midnight in eight digits including one decimal.
30.4.7 Cumulative VARh transmittal for voltage low condition, at each midnight, in eight digits including one decimal.
30.4.8 Average RMS voltage for each successive 5min block.
30.4.9 Date and time blocks of failure of VT supply on any phase, as a star (*)/ (Z) mark.
30.4.10 The meters shall store all the above listed data in their memories for a period of fifteen (15) days. The data older than fifteen (15) days shall be erased automatically
30.4.11 The software provided at CDCS, i.e. SLDC, will manage all functionalities of collection of data through DCUs, validate the data, store the data in a database, and manage the complete system. Software will also have a scheduler for scheduling the task of collection of data periodically. The periodicity of data collection shall be user defined.

30.5 **Display**

Each meter shall have digital display for indication of the following (one at a time), on demand:

30.5.1 Meter serial no. and model : IEM12345678A or IEM12345678B
30.5.2 Date (year month day /yyyy mm dd) : 20160311 d
30.5.3 Time (hour min sec /hh mm ss) : 195527 t
30.5.4 Cumulative Wh reading : 1234567.8 C
30.5.5 Average frequency of the previous block : 49.89 F
30.5.6 Net Wh transmittal during the previous block: - 28.75 E
30.5.7 Net VARh transmittal during the previous block: - 18.75 R
30.5.8 Average % Voltage : 99.2 U
30.5.9 Reactive power (VAR) : 106.5 r
30.5.10 Voltage - high VARh register reading : 1234567.5 H
30.5.11 Voltage - low VARh register reading : 1234567.4 L
30.5.12 Low battery indication
30.5.13 The three line-to-neutral voltages shall be continuously monitored and in case any of these falls below 70 %, a preferably flashing three LEDs (one LED/phase) provided on meter's front shall become steady. They shall go off if all three voltages fall below 70 %. The LED shall automatically resume flashing when all VT secondary voltages are healthy again.
30.5.14 The two VARh registers (xv and xvi) shall remain stay-put while VT supply is unhealthy.

Any other better or more informative mechanism to display the above shall be preferred. The above shall be mutually agreed between the meter buyer and vendor.

Navigation keys to be provided at the meter front plate to navigate the display menu.

30.6 Communication

30.6.1 Each meter must have an optical port on its front for tapping all data stored in its memory through HHU. In addition to the above each meter shall also be provided with a RS-485, Ethernet and USB port on one of its sides, from where all the data stored in the meter's memory can also be transferred to CDCS (through DCU), local computer and external storage. The overall intention is to tap the data stored in the meter's memories at a scheduled time from any of the above mentioned ports or any other means and transmit the same to a remote central computer using suitable means of communication. It shall be possible to securely download the IEM data through an USB port via external storage thereby removing the requirement of a MRI (Meter Reading Instrument). It shall be ensured that data transfer through USB shall be unidirectional only i.e. from Meter to external storage device in an authentication process. Meter data shall be tamper-proof.

30.6.2 All meters shall be compatible with Optical port, RS-485 port, Ethernet port and USB / RS-232 port all together at a time and communicate independently. It shall also be possible to obtain a print out (hard copy) of all data collected from the meters, using the local PC. Data collection from any local laptop/PC shall be possible by installing data collection software. Entire project has to be based on Optic Fibre/GSM/4G/3G.

30.6.3 The Tenderer may design appropriate architecture for providing end to end metering solution. He is free to decide upon the best solution out of all the available options to ensure that data from all IEMs in ASSAM are available at State Load Despatch Centre by the scheduled time. However, the entire responsibility of fully functional end to end metering system shall rest with the Tenderer in order to meet the performance levels as given in this document. The communication provider may adopt Optical Fibre/GSM/3G/4G communication technology or a combination of these technologies as per the site requirement adopting best available technology in the proposed area of implementation. The successful Tenderer shall be responsible for proper data exchange among IEM, DCU, CDCS, MDP and other operational/requisite software as part of fully functional metering system.

30.6.4 The operational testing of all the network elements has to be demonstrated by the Tenderer to the satisfaction of the utility.

30.6.5 The Tenderer shall provide the necessary software which would enable a local PC/ CDCS to:

30.6.6 Accept the data from the Optical/Ethernet/WAN and store it in its memory in user defined formats (text, csv, xls, etc.) in a user-defined file name (file name format must be ddmmyy substation name-utility name).

30.6.7 Polling feature along with a task scheduler to run the data downloading software at a pre-designated date and time repeatedly or by manually selecting a meter. File naming for such downloaded data should also be in user-defined format. A detailed activity log shall also be available for each downloading operation.

30.6.8 Upload/Import meter data (binary files) in the software for further processing. While uploading, there shall be provision to upload all selected files with single key-stroke.

30.6.9 Convert the binary file(s) to text file(s).There should be provision to select multiple files based on filename, convert all selected files with single key-stroke and store the text files in the same location where binary files are stored.

30.6.10 Display the collected data on PC's screen in text format, with forward/backward rolling

30.6.11 Print out in text format the data collected from one or more meters, starting from a certain date and time, as per operator's instructions

30.6.12 Transmit the collected data, in binary format, through an appropriate communication link to the central computer, starting from a certain date and time, as per operator's instructions.

30.6.13 Store the collected data in binary format, on a CD/Pen Drive. In addition to above, in general the software shall be able to convert IEMs data to existing format as well as in tabular (.csv) format as applicable.

30.6.14 The above software shall further ensure that absolutely no tampering (except erasing of complete data with password protection) of the collected metering data is possible during its handling by the PC. The software shall be suitable for the commonly available PCs, (Windows) and shall be supplied to Owner in a compatible form to enable its easy loading into the PCs available (or to be installed by the Owner/others) at the various substations.

30.6.15 The Tenderer shall ensure data integrity checks on all metered data received from data collection systems.

30.6.16 The quality of installation of the various equipment & power supply wiring to all field equipment shall be as per standards/ regulations/prevailing practices of the utility. The supply of electricity needed for operation and maintenance of entire Metering system shall be provided free of cost by the respective owners of the premises.

30.6.17 Climatic Condition

The meters to be supplied against this specification shall be required to operate satisfactorily and continuously under the following tropical conditions of hot, humid, dusty, rust and fungus prone environment.

Maximum ambient air temperature (°C)	55
Minimum ambient air temperature (°C)	(-) 5
Average Daily ambient air temperature (°C)	32
Maximum Relative Humidity (%)	95
Minimum Relative Humidity (%)	10
Maximum altitude above sea level (m)	1000
Average Annual Rainfall (mm)	1200
Maximum Wind Pressure (Kg/sq.m)	195
Isoceraunic Level (days per year)	50
Seismic Level (Horizontal Accn. In g)	0.3

30.6.18 Quality Assurance

The quality control procedure to be adopted during manufacturing of the specified equipment shall be mutually discussed and finalized in due course, generally based on the established and proven practices of the manufacturer. The software shall be user friendly which can be easily installed in any PC/Laptop irrespective of operating system of the PC/Laptop, and shall be certified for ensuring data handling capabilities. The same shall be demonstrated by the party during technical evaluation. During demonstration party shall bring standard meter. Thereafter software shall be offered for technical compatibility before taking up further necessary action in the procurement process.

30.6.19 Testing

All equipment, after final assembly and before dispatch from manufacturer's works, shall be duly tested to verify that is suitable for supply to the Owner. Routine and acceptance tests shall be carried out on the meters in line with IS 14697.

Any meter which fails to fully comply with the specification requirements shall be liable to be rejected by the Owner. However, the Owner may purchase such meters at a reduced price in case of marginal non-compliance, at his sole discretion.

Acceptance Tests for PC Software and data down loading using meter communication ports- All IEMs after final assembly and before despatch from Tenderer's/Manufacturer's works shall be duly tested to verify that they are suitable for downloading data using meter communication ports shall be subjected to the following acceptance test.

Downloading Meter Data from the Meter(s) to PC via optical port.

Downloading meter data through USB port and RS 232.

Downloading meter data to DCU/CDCS through Ethernet as well as RS 485 port.

Compatibility with PC Software.

Functioning of Time synchronisation, advance and retard time commands.

Per meter downloading time verification.

Copy of Certificate shall be submitted.

30.7 Type Tests

i) One (1) meter in a batch shall be subjected to the complete range of type tests as per IS14697 and IS15959, after final assembly. In case of any failure to pass all specified tests, the Tenderer shall arrange to carry out the requisite modifications/replacements in the entire lot of meters at his own cost. After any such modifications and final assembly, two (2) meters selected out of the lot by the Owner's representative shall be subjected to the full range of type tests. The lot shall be accepted by the Owner only after successful type testing.
ii) The meters used for type testing shall be separately identified, duly marked, and supplied to the Owner in case they are fully functional and as good as other (new) meters, after necessary touching up/refurbishing. In case this is not possible, the Tenderer shall provide their replacements at no extra cost to Owner.
iii) The Tenderer shall arrange all type testing specified above, and bear all expenses for the same.
iv) Copy of Test certificate shall be submitted to SLDC.

30.8 ANOMALY DETECTION FEATURES

i) The meter shall have features to detect and log the occurrence and restoration of following anamolies, along with date and time of event: 6.1.1. Phase wise Missing Potential – The meter shall detect missing potential (1 or 2 phases) provided the line current is above a specified threshold. The voltage at that stage would be below a specified threshold.
ii) Phase wise Current Circuit Reversal – The meter shall detect reversal of polarity provided the current terminals are reversed. This shall be recorded for 1 or 2 phase CT reversal.
iii) Voltage Unbalance – The meter shall detect voltage unbalance if there is unbalance in voltages.
iv) Current Unbalance – The meter shall detect current unbalance if there is unbalance in load conditions. Meter should ensure true system conditions before going for current unbalance checks.
v) CT Miss – The meter shall detect current miss if the current is below a defined threshold, provided the phase voltage is above a specified threshold. Snapshots of phase wise voltage, phase wise active current and phase wise power factor shall be provided with above specified anomaly events. Further, each meter module shall record the following events along with total duration:
vi) Power On/Off – The meter shall detect power off if both the auxiliary supplies fail. The event shall be recorded on the next power up. At the same time power on event shall be recorded. No snapshot shall be logged with this event.
vii) Feeder Supply Fail -This event shall be logged when feeder supply, i.e. all the voltages goes below certain threshold. No snapshot shall be logged with this event.
viii) Last three hundred & fifty (350) events (occurrence + restoration), in total, shall be stored in the meter memory on first in first out basis.
ix) There shall be five separate compartments for logging of different type of anomalies :

Compartment No. 1	100 events of missing potential
Compartment No. 2	100 events of CT reversal
Compartment No. 3	100 events of power failure/ Power on-off

Compartment No. 4	50 events of transaction related changes as per ICS Category B

x) Once one or more compartments have become full, the last anomaly event pertaining to the same compartment shall be entered and the earliest (first one) anomaly event should disappear. Thus, in this manner each succeeding anomaly event shall replace the earliest recorded event, compartment wise. Events of one compartment/ category should overwrite the events of their own compartment/ category only. In general persistence time of 5 min. for occurrence and restoration respectively need to be supported in meter.

xi) Anomaly count should increase as per occurrence (not restoration) of anomaly events. Total no. of counts shall be provided on BCS.

30.9 Installation and Commissioning

30.9.1 The Tenderer shall be responsible for total installation and commissioning of the meters (along with test blocks, if supplied separately) as per Owner’s advice, including unpacking and inspection on receipt at site, mounting the meters on control and relay panels at an appropriate viewing height, connection of CT and VT circuits including any required rewiring, functional testing, commissioning and handing over. The Tenderer’s personnel shall procure/carry the necessary tools, equipment, materials and consumables (including insulated wires, lugs, ferrules, hardware etc.)

30.9.2 As part of commissioning of DCDs the Tenderer shall load the software specified in clause 5(d) into the PCs at the respective substations, and fully commission the total meter reading scheme. He shall also impart the necessary instructions to substation engineers. At least 2-hour training session shall be arranged for substation staff and SLDCs. Also, an operating manual (pdf as well as hard copy) of the meter containing all details of the meter, various data downloading features, etc. shall be made available at site and SLDC.

30.9.3 At the time of commissioning, the meters lying in stores shall be time synchronized through GPS signal before installation in the panel to avoid the large time mismatch.

30.9.4 <u>General</u>

30.9.4.1 The meter shall be supplied with latest/compatible software (shall be compatible with old & new meters data download handling). Any new software as required to be installed within warranty period are to be done by party or through remote support to client.

30.9.4.2 The total arrangement shall be such that one (1) operation (click on “data down load from meter” button on software) can carry out the whole operation in about five (5) minutes per meter or preferably faster.

30.9.4.3 The layout of software front end/user interface has to be approved by RLDC during technical evaluation/demonstration. However, a standard template sheet will be provided along with TENDER for reference.

30.9.4.4 Software for windows/office/antivirus to be supplied. Antivirus should not slow down processes and same will be demonstrated during technical demonstration.

30.9.4.5 Above specification is minimum only, any higher standard required for the purpose intended (meter data handling) would be assessed by vendor and would be supplied accordingly. The detailed architecture shall be approved during drawing approval stage.

30.9.4.6 Meter shall be accommodated in existing C&R panel of standard size (Alstom/ ER/ABB/Siemens) in kiosk or C&R panel with door closed. If required before TENDERding, Tenderer may collect necessary data or else the scope is deemed to be included.

30.9.4.7 Step by Step procedure (on screen shot type and desktop video capture) shall be provided for

- Installation/Re-installation of Database handling software in to Laptop / PC
- Meter maintenance/site-testing procedure as per relevant IS/IEC standard
- Procedure for data downloading from Meter by HHU/Laptop/Desktop PC.

As on date of delivery, the supplied meters shall comply with all statutory regulation as required under CERC/CEA/IEGC as applicable and the same should be declared by the vendor during delivery along with warranty certificate.

30.9.5 Warranty

30.9.5.1 The IEM shall be under warranty as per OEM standard Warranty Policy. The Tenderer shall be responsible for meter testing as per CEA metering regulations.

30.9.5.2 The warranty would include repair, replacement, part material replacement cost and one way (return) transportation cost (including insurance of transit)

30.9.5.3 Meter software, if upgraded by OEM should be supplied free of cost with initiation taken from party. Remote service person name to be indicated during TENDERding

30.9.5.4 Meters which are found defective/inoperative at the time of installation or become inoperative/defective within the warranty period, these defective/inoperative meters shall be replaced within one week of receipt of report for such defective/inoperative meters

30.9.5.5 Copy of warranty certificate shall be submitted to owner

30.9.6 STANDARDS TO BE COMPLIED WITH

Standards to be complied

S.No	Reference	Reference Title
	Detail	
1	IS-15959:2011	Data Exchange for Electricity Meter Reading Tariff &
		Load Control – Companion Specification
2	IS-14697:1999	Specifications for AC Static Transformer operated Watt
		Hour & VAR-Hour meters, class of 0.2S and 0.5S
3	IEEE 830-1998	IEEE Recommended Practice for Software
		Requirements Specifications

30.9.7 AMR System

Overview

30.9.7.1 AUTOMATED METER READING or AMR, as the name suggests is a system used for automating the Meter data collection process. AMR to retrieve data from Energy Meters installed in the substation/ Switchyards has to be primarily based on GPRS/4G/3G network and fibre optic communication, where ever available. However in case GPRS/4G/3G network is not available at any location, then any reliable communication service like Broadband & Satellite Communication may be used for communication with CDCS.

30.9.7.2 Meters with RS 485/Ethernet port shall be interfaced with Data Concentrator unit to be installed at the substation. Each DCU shall collect and communicate meter data to CDCS server i.e. MDAS(Meter Data Acquisition Software) installed at the central data center located in each SLDC.

30.9.7.3 The intent of AMR scheme proposed in this document is to automate the task of data collection from each meter/location to the Central Data Collection System (CDCS) followed by validation, processing and generation of customized reports. The data shall be stored in RDBMS database located at respective CDCS server(SLDC).

30.9.7.4 The communication system for data transfer from IEM to SLDC shall be in the scope of the Tenderer. Concept diagram of the envisaged AMR system is given in Figure

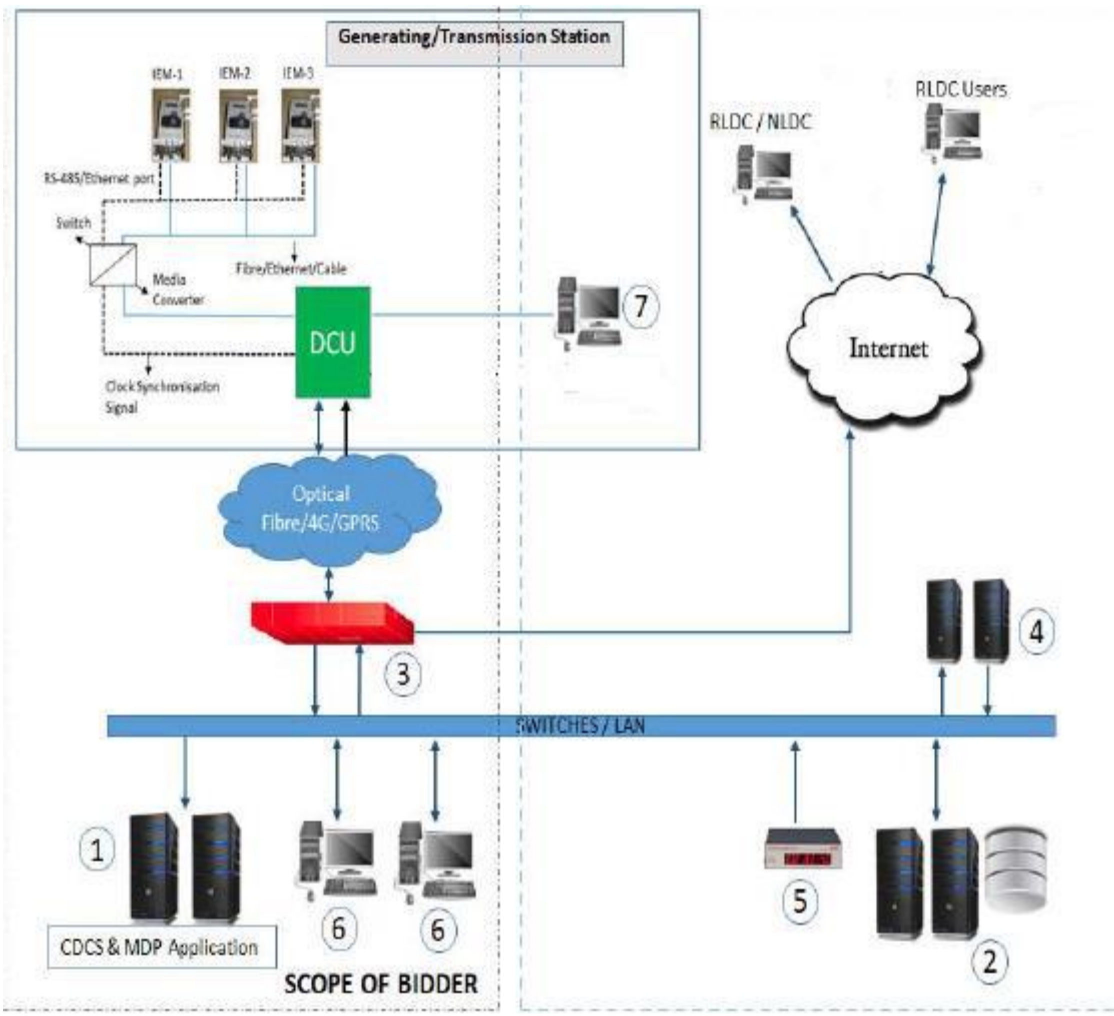

Figure 2: Concept Diagram of Envisaged AMR System

30.9.7.5 AMR Software Features

i. AMR shall be provided for collection and processing of data from ABT(IEM) meters (as specified by SAMAST committee) installed at remote Substations. AMR architecture may include the following 4 parts:

- Data Concentrator Unit (DCU)
- Communication System
- GPS clock
- Centralized Data Collection subsystem (CDCS) (including CDCS server and MDAS software).

ii. Data Centre Communication Server (CDCS) software shall perform following functions:-

- Communication with DCUs
- Collection of energy meter data
- Collection of status data from DCU
- Remote Configuration of DCU
- Processing of energy data
- Storing of data
- Reporting functions for network and communication
- Monitoring and Alarming
- Audit trail and logging.

30.9.7.6 Data Concentrator Unit

i) A Data Concentrator Unit (DCU) installed at each location will act as interface between Central Data Collection System (CDCS) at SLDC and IEMs installed at that location.
ii) DCU shall collect data from energy meters and sent the same to CDCS at SLDC.
iii) DCU shall also report diagnostic information of the energy meters to CDCS. DCU shall have following functions: -
iv) Acquiring energy data and status from energy meters.
v) Providing energy data and status to CDCS
vi) Providing energy data and status to local computer.
vii) Intelligence to synchronize IEMs clock with GPS clock located at CDCS.
viii) Each meter has a unique identification number and each meter location has unique Identification code. DCU shall collect data from a single or group of meters based on meter number and meter location code. DCUs shall collect data from energy meters and transfer the same to CDCS. DCUs should provide a RS-485/Ethernet/USB port for Communication with local personal computer or terminal.

30.9.7.7 Central Data Collection System

A Central Data Collecting System provided at SLDC will manage all functionalities of collection of data through DCUs, validation and verification of the data, storage of the data in a database with RAC and with HA (High availability provided by remote mirroring of database storage) and management of the complete AMR system. CDCS shall have a scheduler for scheduling the task of collection of data periodically up to the last time block. Provision of extracting data from the database in the text files as per existing format for all or selected meters for further processing by Energy Accounting software is also to be built in data collection software. The responsibility of providing data up to CDCS (including all the hardware in between) shall be the responsibility of the Tenderer.

The Supplier shall supply, install and commission the CDCS server including the MDAS software on the CDCS server. The awardee under the tender "Supply, Installation, Testing and Commissioning of IT solution as part of Scheduling, Accounting Metering and Settlement of Transaction (SAMAST) system at State Load Dispatch Centre in the North Eastern States of Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland and Tripura" shall install the housing/rack for CDCS server and associated equipments in the SLDC premises and make the same available to the Tenderer under this tender as per the project milestone of the former tender.

30.9.7.8 Communication System

For the purpose of this project communication media i.e. Fiber Optic/GPRS shall be provided by the respective utility. However for the Pilot Supplier will have responsibility to establish the same. Communication system to be used for transfer of data from DCU to CDCS may be through Optic fibre /GSM-2G/ 3G/ 4G. Tenderer is free to suggest alternative reliable communication media if it is more efficient and cost effective. The Tenderer may conduct field survey for the same prior to submission of tender.

Scope of Work

This section provides detailed scope of work included in the Tenderer’s scope, excluded from the Tenderer’s scope, facilities to be arranged by Tenderer and facilities to be provided by station owner.

Tenderer’s Scope of Work

The scope of work in complete conformity with subsequent sections of the specification shall include site survey(prior to tendering and during execution), planning, design, engineering, manufacturing/integration, FAT test , supply, transportation & insurance, delivery at site, storage, installation, commissioning, demonstration for site acceptance, training and documentation of AMR system including:

- Design Document for complete AMR System.
- Software Requirements Specifications for CDCS/MDAS and DCU.
- MDAS output format shall include exposing APIs (in Json format).
- Application Server Database System and Central Data Collection System (CDCS) at SLDCs.
- CDCS server along with Router for installation of MDAS (Meter Data Acquisition System) at SLDC.
- Making data available up to CDCS system at SLDC.
- Data Collection Unit (DCU)
- Connection and interfacing of meters with DCU.
- Supply and laying of optical fiber at the stations for connection of IEM to DCU wherever the Ethernet/serial communication not feasible
- GSM/GPRS/ Modems, Media converter, Switch
- Communication channels between each DCU and CDCS.
- All cabling, wiring, terminations and interconnections of the equipment.
- Database development, Displays and Reports.
- Archival and retrieval of data through database with RAC and with HA (High availability provided by remote mirroring of database storage) database at SLDC.
- Decoded text files in existing format at SLDC.
- Periphery segregation shall be in line with established cyber security standards.
- Training of personnel (Substation, SLDC and other divisions of the respective state utility)
- Warranty for 1 years. The intent of the project is that the Tenderer shall ensure 100% data availability at SLDC within the stipulated time as per IEGC within the warranty period.
- To maintain extra 20% quantity of AMR equipment as backup and future requirement.

30.9.7.9 Functional Requirements:

30.9.7.9.1 Major components of the AMR System to be implemented under the scope of this specification document are

- Data Concentrator Unit
- GPS clock
- Central Data Collection System (CDCS) or Meter Data Acquisition System (MDAS).
- Communication channel

This section enumerates the functional requirements of each component.

30.9.7.9.1.1 Data Concentrator Unit (DCU)

DCU is to function as a gateway between Central Data Collection System (CDCS) and energy meters installed at DCU location. DCU shall have following functions: -

- Acquiring energy data and status from energy meters.
- Providing energy data and status to CDCS.
- Providing energy data and status to local computer.
- Time synchronization of IEM’s, either through GPS installed at site or through CDCS
- Provision for Interface between DCUs

Application Requirement: Data Concentrator Unit (DCU) along with the suitable enclosure shall be placed in the control room in the Substation/ Generating Plant. DCU is functionally requires to acquire the IEM data and transferring the same to Data Control Center (SLDC) using communication system and AMR software.

30.9.7.9.1.1.1 General Construction

i) DCU shall be a self-contained, stand-alone box with minimum 1 serial (RS485) port for meter connection and with one RJ45 Ethernet 10/100/1000mbps port. DCU shall have in built modem or external modem facility. DCU shall have MODBUS port in addition to DLMS.
ii) DCU should be flush mounted or surface mounted and to be supplied with suitable enclosure for installation in the control room. The enclosure shall be complete with the internal wining and have all the necessary arrangement for the termination of various communication and power cables in the enclosure.
iii) DCU should be of reputed make and should be field tested in similar application for central govt /state govt./PSU etc. DRS/data sheet approval will be taken during drawing approval stage
iv) The DCU shall be normally powered from the station battery backup supply rated at 110/220 VDC/ 230VAC.
v) DCU should have protection against entry of dust.
vi) Substantial EMI (Electro Magnetic Interference) and ESD (Electro Static Discharge) will be present at DCU site, effect of which shall be duly considered while designing the system. Performance of the overall system shall not be hampered by such interference. EMI/ESD tolerance shall comply with IEC61850-3 guidelines.
vii) DCU should be able to operate in environment with temp up to 45°C and humidity up to 90% without any significant effect on its performance.
viii) The mechanical design and construction of each unit sub-assembly shall be inherently robust and rigid under various conditions of operation, adjustment, replacement, storage and transport.
ix) DCUs shall also withstand without any damage or mal-operation reasonable mechanical shocks, earthquake forces, ambient temperature variations, relative humidity etc. They shall have an IP-54 or better category dust-tight construction, and shall be capable of satisfactory operation in an indoor, non-air-conditioned installation.
x) Local Display and LEDs for status like power on, communication activity etc should be provided on the face of DCU.

30.9.7.9.1.1.2 Acquiring energy and status data from energy meters

i) DCUs shall be connected with local energy meters through Ethernet/Serial/USB optical fiber with suitable media converter/ switches in between. All communication between meters and CDCS via DCU should be firm and secure from any unintended disconnection. DCU should implement IEM protocols (IS 15959- Data Exchange for Electricity Meter Reading Tariff & Load Control – Companion Specification). It shall be possible to change/update the energy meter protocol driver from CDCS. DCU shall store the energy data from the meters for at least 15 days in its memory. DCUs shall not send any command other than the command to read the energy data, status data and GPS clock synchronization of IEM clock.
ii) DCU shall be capable of synchronizing with GPS locally/Remote and transfer the synchronizing signal to all the IEMs connected to it. The necessary ports for time synchronization shall be made available. Status means data healthiness check of DCU & Communication channel and any status given by meter.
iii) Providing Energy Data and Status to CDCS
iv) DCUs shall be provided with suitable SIM/modem etc. in order to have connectivity over Optic Fibre /GSM/ 3G/ 4G with SLDC. All communication between DCU and CDCS shall be on secure VPN with two IP address. DCU shall accept following commands from CDCS/GPS Clock and shall function as per the command:
v) Energy data collection from energy meters.
vi) Acquiring status and alarm from energy meters.
vii) Modification of DCU Configuration through remote access from CDCS.
viii) IEM clock synchronization with GPS clock from CDCS.
ix) The DCU should be compatible with two SIM's and should have provision for Ethernet connectivity with fall back option between them. Tenderer may supply separate modem with DCU as per technical specifications specified herein.

x) Transfer of data from DCU to MDAS should be on physical Ethernet and secured VPN form. The DCU should be able to run the meter protocol drivers to read each type of meter and transfer them to the Control Centre. The DCU must support DLMS/COSEM (HDLC & TCP) as well as MODBUS to communicate with meters.

30.9.7.9.1.1.3 Energy Data Collection

i) DCUs shall query energy data and transfer the same to CDCS based on the command received from CDCS. Command may be for one time demand of data or it may be on cyclic basis. DCU shall be able to query data from all or selected energy meters for the selected period based on the command from CDCS. DCUs shall be able to read energy data from all make of energy meters available in the market like L&T, Secure and Genus etc.
ii) Each meter has a unique identification number and location identification code. DCU shall collect data from a single or group of meters based on meter number or meter location code.
iii) DCU shall receive complete data from energy meters and send the same to CDCS within specified time guaranteed by the vendor. This performance requirement shall be met under the maximum number of IEMs as specified for the delivered as-build or expanded system.

30.9.7.9.1.1.4 Providing energy data to local computer

DCUs shall provide RS-485/Ethernet/USB port for communication with local personal computer or terminal. DCU shall provide meter status, alarm etc. and energy data to local personal computer, if required. Local PC shall be able to query energy data from selected or all energy meter by using web browser and intuitive user interface. The web browser shall be same as CDCS web browser to access the IEMs installed at local station. No special software should be required to be installed at local computer for this communication. All communication with local computer shall be password protected. PC for data downloading at each DCU location shall be arranged by respective site.

30.9.7.9.1.1.5 Status Data Collection

DCUs shall query periodically all energy meters connected to it for status or any alarm etc. Any change in status or alarm shall be reported to CDCS immediately.

DCUs shall acquire connected energy meter details like meter identification number, make, Low Voltage flag etc. periodically as well as whenever it's powered on. Any meter change activity like meter number, Low Voltage flag etc. shall be reported to CDCS immediately. DCUs shall be self-monitoring for alarm like power failure, communication disconnection, and disconnection from energy meters and report the same to CDCS immediately. DCUs shall have non-volatile memory for storing status data of energy meters duly time stamped, details of connected meters like make, meter number, status change. Non-volatile memory should be able to store such data for at least one month in round FIFO buffer.

30.9.7.9.1.1.6 Time Synchronization of Meters

DCU shall have the intelligence to synchronize the IEM clock time with updated RTC clock time. DCU will get GPS clock reference from its respective CDCS (at SLDC) / local GPS clock and synchronize RTC clock time in DCU. The RTC of DCU should retain its synchronized clock signal without any drift for at least 12 hrs.

The CDCS/MDAS Software should generate a report of the drift between the Meter time and DCU time for the purpose of reconciliation.

30.9.7.9.1.1.7 DCU Configurations change

i) Each DCU shall have a unique identification number normally not required to alter at site. DCUs shall accept and respond command for making configuration changes in DCU like periodicity of energy data/status data collection/GPS clock signal for IEM clock synchronization. For each configuration change, DCU shall respond with task successful or failure message to CDCS. Configuration commands from CDCS may be in the form of single command or multiple commands in a command file.

ii) DCU shall accept and make changes in configuration through data command on Optical fibre /GSM-2G/ 3G/ 4G. DCU shall receive the configuration command from CDCS on same channel used for transfer of data to CDCS. DCUs shall store all configuration data locally in a separate non-volatile memory. All changes to configuration shall take place first to this memory. Only after receiving a specific command from CDCS, the saved configurations should come into effect. However, any other functionality should not get affected during accepting and responding to configuration commands from CDCS. DCUs are not required to store history of configuration changes as all history shall be maintained in CDCS.

iii) Similarly, it shall be possible to upgrade the DCU firmware remotely from CDCS based single or multiple commands from CDCS. The firmware upgrade shall come into effect only after receiving the specific command from CDCS. The DCU shall immediately send the status of firmware upgrade to the CDCS and shall provide the old as well as new firmware versions.

iv) It shall also be possible to roll back the firmware upgrade if required.

30.9.7.9.1.1.8 <u>Type Test Requirements of DCU (Tenderer should provide valid type test certificates along with the bi document)</u>

List of Type Tests for DCU

Type Test Requirements of DCU	
Conducted Emission	CISPR 22: 2008-09, Ed 6.0 EN55022:2006/A1:2007 on power lines and signal ports
Radiated Emission	CISPR 22: 2008-09, Ed 6.0 EN 55022:2006+A 1:2007 Class A 30Mhz to 1000Mhz
Electrostatic Discharge	IEC 61000-4-2:2001 - ±8 kV Contact Discharge, ± 15 kV Air Discharge
Radiated Susceptibility	IEC 61000-4-3: 2006 -80 - 1000 MHz : 10V/m 80% AM, 1 kHz sine wave
Electrical Fast Transient	IEC 61000-4-4:2004 - ±4 kV serial ports, Ethernet port, DC Power Ports
Surge Protection	IEC61000-4-5:- 2011 Serial port ± 4kV, 1.2/50 μs for common mode, Ethernet port ± 2kV, 1.2/50 μs for common mode DC Power port ± 2kV, 1.2/50 μs for common mode, ± 1kV, 1.2/50 μs for differential mode AC Power port ± 4kV, 1.2/50 μs for common mode, ± 4kV, 1.2/50 μs for differential mode
Induced (Conducted) RFI	IEC 61000-4-6: 2004 - 0.15 - 80 MHz : 10 Vrms 1 kHz, 80%AM for DC power, serial and Ethernet port
Power Frequency Magnetic Field	IEC 61000-4-8: 2001 -40 A/m & 1000 A/m
Damped Oscillatory Magnetic fields immunity test	IEC 61000-4-10 T rise: 75 ±- 20% Oscillation frequency 1MHz: ±- 10% Repetition rate: 400 /s for 1 MHz ± 10%, Burst duration: Not less than 2s Continuous magnetic field strength: 30 A/m
Voltage AC Dips & Interruption	IEC 61000-4-11 - AC Power port 0% short Interruption for 250 cycles, 0% of AC mains voltage for 0.5 cycles and 1 cycle, 40% dips for 10 cycles, 70% dips for 25 cycles, 80% dips for 250 cycles

Damped Oscillatory Wave	IEC 61000-4-12 Damped Oscillatory Frequency: 1 MHz Common Mode: up to ± 2.5 kV Differential Mode: up to ±1.0 kV for power port 1 MHz Common Mode: up to ± 2.5 kV for serial port 1 MHz Common Mode: up to ± 2.5 kV for Ethernet port
Immunity to Conducted Common mode disturbances	IEC 61000-4-16 Ed 1.1 frequency range 0-150kHz
Ripple on DC power line immunity test	IEC 61000-4-17 10% of the Nominal DC voltage AC line frequency 50Hz on DC power port
Voltage Dips & Interrupts	IEC 61000-4-29: 2000 - 0% short interruption for 0.03 sec, 40% and 70% dips for 0.3 sec, 80% & 120% variation for 3 sec
Impulse voltage Immunity	IEC60255-5 2000-12, Ed2.0 ±5kV for power port and earth
Barometric Pressure test	IEC 60870-2-2 Ed 1.0 Test range 0 (101.3 kPa) to 3000m (70.0 kPa)
AC Voltage Range and Tolerance test	IEC 60870-2-1 Ed 2.0 176 Vac (-20 %) to 253 Vac (+15%)
Cold Temperature test	IEC60870-2-2 tested at -40 ^{o}C
Hot temperature test	IEC60870-2-2 tested at 70 ^{o}C
Humidity test	IEC60870-2-2 95% RH 55^{o}C and 55^{o}C
Vibration and Shock test	As per IECC60870-2-2, Class Am, 5Hz to 500Hz on X,Y, Z axis, 10g in X,Y, Z axis
Green Product	RoHS

30.9.7.9.1.1.9 Central Data Collection System (CDCS)

A central data collection system (CDCS) shall be provided at SLDC for collection and processing of data from DCUs installed at remote locations. CDCS shall perform following functions: -

i) Communication with DCUs
ii) Collection of energy data from DCUs
iii) Collection of status data form DCUs
iv) Remote Configuration of DCUs
v) GPS clock signal to DCU
vi) Processing of energy data.
vii) Storing of data.
viii) Providing data to energy accounting software.
ix) Reporting functions.
x) Monitoring and Alarming.
xi) Audit trail and logging.
xii) Meter management.
xiii) Shall have user Interface for Data/Report uploading on website.Data/Report access for predefine list of meters to SLDCs with secure user name and password for intrastate energy accounting.

xiv) In case of AMR communication system failure due to any reasons manual provision should be made for uploading IEM data to the MDP software for energy calculation.

xv) CDCS shall include a web-based application for utilities/stations to manually upload the data in case of AMR communication system failure due to any reasons. The following shall be taken care of in this regard:

xvi) The web application link shall be made accessible to all stations through SLDC website.

xvii) The downloaded data shall be in encrypted format.

xviii) Each utility shall be given User name and Password for login the web application.

xix) Browser shall have the list of all Utilities and its station names.

xx) Each station shall upload the encrypted data by selecting their Utility name and Station name.

xxi) Web Application shall generate the confirmation message to the station on successful uploading of data.

xxii) Web application shall generate the popup message at CDCS with Utility name and Station name on receipt of data.

xxiii) All the encrypted data received at CDCS via web application shall be stored in predefined path.

xxiv) CDCS shall have the provision to decrypt the data and store in the database for the further processing.

xxv) Communication with DCUs

The CDCS shall have a dedicated Communication Server – This shall manage the VPN Connections, DCU Communication, Alarm management, Logging, DCU Configurations as well as GPS clock signal to DCU. The Interface of the Communication Server shall be standards based such that, up gradation of either Communication System or Application Server will not need a commensurate replacement of the other. The CDCS shall have a Network Management Interface that provides a Dash Board of the DCU's and their status / Alarms and Meter's that are not communicating.

xxvi) Collection of energy data from DCUs

CDCS shall collect data from energy meters through DCU for selected/configured meter location periodically or on demand at any time. CDCS shall have a scheduler software, which shall issue command to the concerned DCU and collect the required energy meter data. It shall be possible to schedule data downloading on hourly basis.

xxvii) Collection of status data form DCUs

CDCS shall have a DCU monitoring module. This module shall monitor each DCU for its working status, parameters and any alarm etc. The monitoring data shall be collected periodically or on demand at any time from all or selected DCUs.

xxviii) Remote Configuration of DCUs

CDCS shall be provided with software module for remote configuration of selected or batch of DCUs. Remote DCU configuration module should be able to configure each parameter of DCU individually or in batch mode. It shall be possible to download the following changes to the remote device in addition to other required changes:

Poll cycle for collection of energy data.

Fixed public IP of CDCS server of the Control Centre

Changes in meter protocol driver

xxix) GPS clock signal to DCU

CDCS shall send time sync signal to DCU to time synchronize the IEMs connected to that DCU. CDCS shall check the time in each meter on a pre-configured interval (say once a day) and if the drift in meter clock is more than maximum allowed drift (say 60 seconds) with reference to GPS time, the DCU shall initiate clock synchronization in incremental manner with pre-configured offset interval(say 10 seconds). Tenderers can propose alternate mechanisms with the objective keep all the meter clocks within 60 seconds drift with reference. Any meter time change command initiated by the AMR system should be logged as part of audit trail.

xxx) Processing of energy data

Collected energy meter data (5-min) shall be provided to the data processing module. The time block period of the raw output from CDCS shall be user defined (5 min). This module shall check the data for completeness, error etc. and if any error is found, the same shall be displayed as an alarm.

xxxi) Storing of data

If collected data is error free, it shall be provided to a data storage module. Data storage module shall load the collected energy data in to the database as per its structure. Archival of data shall be through RDBMS data base. CDCS shall provide online storage for storing a minimum of 10 years of collected, processed and output data.

CDCS event archive data storage historian shall provide a minimum data storage of 10 years, assuming event will not be more than 20% of the total time.

Providing data to energy accounting software

CDCS should have software module for providing energy meter data from the database to the energy accounting software. The data output shall be in the form of text file (as per IEMs standard text file format) or as query-based output.

xxxii) Reporting

CDCS shall have data reporting capability implemented through a separate dedicated module. Reporting module should be able to give report output on screen, in pdf or in xls/csv form. Reports may be based on pre-configured criteria or based on adhoc query.

xxxiii) Monitoring and Alarm

CDCS at SLDC shall provide DCU monitoring and self-monitoring functions to monitor the operating conditions and the performance of the system.

A suitable network management system (NMS) shall be provided at CDCS to monitor the performance of the communication network round the clock. The NMS shall provide viewing of all the networking elements deployed at site and enable configuration & parameterization of the networking devices and the nodes.

Any detected problems shall be reported through local display, built-in event logging and to remote console or printer. Severe problems, such as loss of communication, shall generate alarms locally and e-mail notifications to configured e-mail address. User shall be able to enable and disable alarms individually.

CDCS shall generate an alarm whenever “data not received” occurs for one or more times for one or more DCU/IEM data. The alarm shall indicate which DCU/IEM has the problem. All Alarms (such as loss of supply to IEM, DCU failure, Communication failure, AMR failure etc.) to be generated in CDCS within 5 min. of the event.

xxxiv) Performance levels for AMR and CDCS

Data from all the installed IEMs shall be received at CDCS within 8 hours after the scheduled hour (as per user defined). Report for missing data if any shall be generated instantly on demand.

Issues observed in data collection, processing, report generation etc. shall be flagged by SLDC to the vendor for speedy redressal.

xxxv) Audit trail and logging

CDCS should have audit and logging function for each and every activities either completed successfully or failed should be logged. The system shall provide audit trail of user and system activities that enables data changes to be tracked and reported, including changes made by the system administrator. For editing of energy meter data, the system shall record the following information in a log and store it for a minimum of 12 months:

- User ID
- Date and Time of Change

User shall be prompted to input a reason for editing using either a standard reason code or a freeform text field. In addition to data stored in the edit log, each interval containing edited data shall be marked with a status to indicate that the data has been edited. The pre-edited value shall be stored in the database as a previous version, which can be retrieved using “as-off” date functionality.

Changes to configuration data by users shall be logged by Date, time, and user ID and such logs shall be stored for a minimum of 12 months. Critical changes relating to measuring parameters (pulse multipliers, transformer ratios, etc.) and formulae change shall be stored indefinitely as a previous version. The database for these is to be maintained in CDCS. For regular system tasks, such as meter communication, task processing, validation, etc. the information will be kept for minimum one month. Full data and system audit ability such as version controls and data retrieval according to the date and time. Additionally, all versions of meter data shall be stored such that they may be retrieved by “as-off” date for user to inspect.

xxxvi) Email & SMS Alerts

CDCS Application software shall have the option to send alerts and notifications via SMS and email to authorized users (operators or maintenance personnel). This shall be used to configure alerts for critical events such as communication device failure, IEM failure, DCU failure, Power supply failure, data collection error reports etc. The software should have option to email reports generated in the system as email attachments.

xxxvii) Data collection, Validation of Data & Reporting

The intent is to provide the requirement details of database-oriented software having capability to exchange and share data/ information with similar database systems that may be used by SLDCs with a view to meet requirements of Data Warehousing and BI systems. The client interface should be browser or console based and report formats should be in user defined multiple formats like PDF, MS Excel, CSV, Text etc.

xxxviii) Collection, Processing and Computation of Meter Data

While importing data from CDCS to software, any discrepancy or missing of data in any particular block or wrong raw data format shall be displayed and downloaded in the form of a report. The output format shall be station-wise, Utility wise and period wise

Software shall have the option to generate the list of meter IDs whose data is not available, List of meter IDs whose data is available for day wise for the required period.

The computation of meter data from IEMs shall be done automatically after activating the import option for data fetching from CDCS

All meter data computation (Active Energy, Reactive Energy, Voltage etc.) shall follow configured Time Blocks region wise Software shall have the provision to access and correct the IEMs raw data in database, if required. The corrected raw data shall replace the old data. It may be noted that multiplication factors are accounted in the meter itself and the practice of applying multiplication factors of CT/PT needed to be dispensed with to reduce computational effort on servers.

xxxix) Validation of IEM and Fictitious Meter

IEMs and fictitious meters are classified in 3 categories

- Main Meters
- Check Meters
- Standby Meters

a) Prior to energy accounting, validation and IEMs and fictitious meters data is essential for accurate energy accounting
b) Validation of main meters data is done by pair-checking and that with Check and stand-by meters data by block wise (5/15 minutes)
c) The validation of data, software shall have a pair configuration file where all set of pairs can be defined.
d) Pair check file shall be user configurable for addition/ deletion/ modification of pairs in accordance with the change in network configuration.
e) When pair check option is activated, Software shall compute the difference between the selected pairs and shall generate the output file which shall consist of actual difference and percentage of difference.
f) Generally, the polarity of Main and Check meters is same as whereas polarity of main and stand-by meters is reverse. The software shall compute accordingly.
g) For calculating percentage difference, the reference energy value shall be the sending energy value for Main-Standby meter (M-S set). Since polarity of main and check meters is same, the main meter energy data shall be considered as reference for pair check of Main- Check meter (M-C) Set.
h) Sending end can be decided based on the polarity of the meter data (Sending end polarity is +ve , while receiving end polarity in –ve).
i) Software shall generate the pair check output file which contains block wise difference and percentage difference values of all pairs whose %age difference is greater than tolerance value).
j) Tolerance %age value shall be user defined and it may vary from element to element. The tolerance value shall be user give in pair check configuration file for each pair.

xl) Data Exchange Facility for integration with SAMAST Software

The proposed AMR solution will have facility to integrate with proposed SAMAST software. The AMR Vendor needs to share data in format desired by SLDC through Application Programming Interfaces (APIs) / web service model with proposed SAMAST software.

xli) Reports

Software shall have the feature to prepare reports (5/15/ minutes) in user defined Text, PDF, Excel and CSV format

Active Energy Reports

Software shall have the capability to prepare day wise active energy reports of utilities. The report shall be prepared for each utility. The formats shall be user configurable

Voltage Reports

Software shall have the option for preparation of voltage reports (5/ 15 minutes) for required meters. The files should be user configurable

The format for 5/ 15 minutes block wise Voltage reports should be same as that of active energy reports

Software shall have the option for preparation of low voltage logging reports (5/ 15 minutes) (as per user defined limits)

Software shall fetch the details of the meter ID which have recorded low voltage.

Frequency Report

Frequency data of reference IEM shall be used for DSM accounting. If main reference meter data is not available, first standby meter data frequency data shall be used for accounting. If both main and first stand by meters data are not available for a particular period, second stand by meter frequency data should be used for these periods. The software shall have a user frequency configuration file for selection of any of the reference IEMs.

The finalized frequency by as per user of SLDC to be exported to proposed SAMAST software and Website and others as per SLDC requirements.

S/W shall have the module to compare the frequency data recorded by all IEMs with reference IEM frequency data and to generate the report/trend for any required period (Date and Time through query. The module shall also have the option to define frequency tolerance value. If difference in the frequency data is greater than the tolerance then report shall show the same.

xlii) Issues to be addressed during Data Validation

As the input raw data is in 5-min blocks all computations in new data processing software shall be done in 5-min only

While Reports generation, Data Processing Software shall provide two options two generate processed data reports in 15/5-min depending upon the user requirement.

The format of the 15-min processed data reports shall be exactly same as that of the existing 15--min processed data reports in text tiles

xliii) Graphs/ Trends

Software shall have the option to display the graphs/ trends in user defined standard chart type such as line, scatter plot, bar chart etc. of different electrical quantities (energy, voltage, frequency etc.) already stored in database for the required period (date and time) through query.

There shall be provision to download the graphs/ trends in required formats (JPEG, PDF etc.)

The X and Y axis parameters of the graphs are user definable

xliv) Data Exchange

The solution will have facility to integrate with proposed SAMAST software. The AMR Vendor needs to share data in format desired by SLDC through Application Programming Interfaces (APIs) / web service model with proposed SAMAST software.

30.9.7.9.1.2 GPS CLOCK

i) The GPS clock will be installed at each SLDC. The GPS clock must have the intelligence to synchronize with NAVIC signal/ NTP/SNTP output.
ii) The Time synchronization equipment to be installed on one of the existing panel at site, shall receive the Coordinated Universal Time (UTC) transmitted through Geo Positioning Satellite System (GPS) and synchronizes equipment to the Indian standard time in a SLDC. Equipment shall have real time digital display in Hour, Minutes and Seconds (24 Hours mode). Standard will be relevant IEC & IS (15959) in line with this document.
iii) Time synchronization equipment shall include antenna, all special cables and processing equipment etc. The length of the Cable for antenna shall generally be Max. 30 Mtrs. However depending on the special requirement, additional length of cable shall be supplied wherever required, without any extra cost
iv) It shall be compatible for synchronization of CDCS.
v) Equipment shall be able to operate up to the ambient temperature of 50 degree centigrade and 95% humidity.

vi) The synchronization equipment (TSE) shall have 2 microsecond accuracy equipment shall able to meet real time corresponding to IST (taking in to consideration all factors like voltage & temperature variation, propagation & processing delay etc)

vii) Equipment shall meet the requirement of IEC 60255 for storage & operation

viii) The system shall be able to track the satellites to ensure no interruption of synchronization signal.

ix) The output signal from each port shall be programmable at site for either one hour, half hour, minute or second pulse as per requirement.

x) The equipment offered shall have Minimum seven (7) output ports. Combination of output ports shall be following: -

- Potential free contact (Minimum pulse duration of 50 milli seconds): 01 No.
- IRIG-B: 02 Nos.
- RS232C: 01 Nos.
- SNTP port: 02 No.
- Unmodulated/modulated : 02

xi) Ethernet

The equipment shall have a periodic time correction facility of one second periodically.

Time synchronization equipment shall be suitable to operate from 220V DC (or) 110V DC as available at Substation.

GENERAL: Tenderer has to supply the suitable connectors of all seven Outputs of the TSE. In case of IRIG-B, T type connectors will be supplied for Looping.

xii) General Requirements

Components of AMR system shall meet following requirements:

xiii) Data Concentrator Unit (DCU)

a) DCU shall be a self-contained, stand-alone, tamper proof sealed box with necessary ports for external connection. It shall be flush mounted or surface mounted without requirement of a separate panel
b) DCU should be of reputed make and should be field tested in similar application for central govt /state govt./PSU etc. DRS/data sheet approval will be taken by drawing during drawing approval stage
c) All components inside DCU shall be easily accessible for testing. The plug-in units, whose removal or insertion, when in operation might endanger the reliability or performance of the unit, shall have suitable protection
d) Each sub-assembly inside DCU shall be clearly marked to show its function, schematic reference so that they are identifiable from the component layout diagram in the handbook
e) All external connections to DCU should be secure so as to avoid accidental disconnection.
f) The DCU shall be powered from the station battery backup supply rated at 110 V/220V DC supply or UPS supply
g) DCU shall have protection against entry of dust, lizards, Rats etc.
h) Substantial EMI (Electro Magnetic Interference) and ESD (Electro Static Discharge) will be present at DCU site, effect of which shall be duly considered while designing the system. Performance of the overall system shall not be hampered by such interferences. EMI / ESD tolerance shall comply with IEC 61850-3 standard.
i) DCU shall be able to operate in environment with temperature up to 50ºC and humidity up to 95% without any significant effect on its performance.
j) The mechanical design and construction of each unit sub-assembly shall be inherently robust and rigid under various conditions of operation, adjustment, replacement, storage and transport
k) DCUs shall also withstand, without any damage or mal-operation, reasonable mechanical shocks, earthquake forces, ambient temperature variations, relative humidity etc. They shall have an IP-51 category dust-tight construction and shall be capable of satisfactory operation in an indoor, non-air-conditioned installation.
l) A local display for status like power on, communication activity etc. and alarms like power failure communication fault etc. shall be provided on the face of DCU

m) A web-based display of DCU dashboard displaying all status; logs of activities, logs of alarm etc. shall be provided which shall be accessible from local PC as well as on CDCS

n) All communication between DCUs and CDCS should be end to end encrypted through secured Virtual Private Network (VPN) tunnel which shall be transparently managed between each DCU and the CDCS by the M2M Gateway/communication Server

o) Transfer of data from DCU to CDCS should be on TCP/IP over Fibre optic communication or using GPRS.While using GPRS the communication between DCU and the communication server/M2M Gateway should be on dynamic/virtual IP so that the communication is operator independent for all DCU's communicating simultaneously with different service provider-based SIM cards

p) For communication with CDCS, each DCU should be provided with Ethernet port, Serial port option for integration with existing Fibre Optics communication media. If any media converter is required for the integration, Tenderer has to supply the same. This is needed even for substation that presently does not have FO communication since FO communication is likely to be added in the future. For locations that do not presently have FO communication, built-in GPRS modem of DCU /external modem must be capable of transferring the data to CDCS

q) For GPRS Mode of communication the DCU should have provision for two SIMs from two different service providers (best available internet service provider of that particular site) with provision of fall back between the two SIM's in case of failure of communication with one SIM

r) For Substations where FO communication /PSTN is implemented, the GPRS mode of communication should be capable to be configured as back up communication mode

s) All modem/SIM installed shall be securely and firmly mounted on DCU itself

t) Mounting or un-mounting of modem/SIM shall be accessible from front of DCU

u) It shall be possible to change modem/SIM without uninstalling DCU

v) Mounting of modem/SIM shall be sealable

w) The Modem shall meet the following environmental specifications, IP55 housing, Storage Temperature: -20 degrees to +70 degree Celsius, Operating Temperature: - 10 degrees to +60 degree Celsius, Humidity: - 95% RH (Non - Condensing)

Item	Description
PORTS:	15 Ethernet Port* (for Meter interface),1 RS 485 PORT,1 SERIAL PORT, 2-4 USB, 1 or 2 GPS Clock synchronous port. *Suitable network switch to be considered for interface between meters and DCU in case of Ethernet communication
SUPPLY:	Station battery backup supply rated at 110V/220V DC supply or UPS supply.
SIM:	DUAL SIM, INBUILT GPRS MODEM
STORAGE:	ATLEAST 15 DAYS OF DATA
OPERATING TEMP:	-10 degrees to +60 degree Celsius:
HUMIDITY:	- 95% RH (Non - Condensing)
DUST	IP-51 CATEGORY
PROTECTION	
COMM.PROTOCOL	TCP/IP while OPGW / GPRS
Max Meters/DCU	15
COMPATIBLITY	DLMS/COSEM STANDARD
COMMUNICATION REQUIREMENT	Should be able to communicate with at least 2 IPs.

Earthing	The DCU, Communication terminal equipment's, HUB and all associated equipment's of AMR at site to be properly grounded at two places through suitable copper strip/bundled wire. The earthing strip will be connected to existing grid strip/flat/ and healthiness of earthiness & any additional requirement (viz. Spike V guard etc.) will be full-filled by Tenderer as required telecom/metering/communication equipment as supplied & installed by Tenderer

x) Notwithstanding the above, the MODEM should meet the following specifications:
y) Standard and Convenience
z) Dual SIM, Dual Module and ACTIVE/ACTIVE mode supported
aa) Support standard RS232 (or RS485/RS422), Ethernet & WiFi port that can connect to Serial,
bb) Ethernet & WiFi devices directly.
cc) Support standard WAN port & PPPoE protocol that can connect to ADSL directly
dd) Enter into communication state automatically when powered
ee) Support several work modes
ff) Convenient configuration and maintenance interface WEB or CLI

Features

a) Support Master module, Standby module and WAN (PPPOE, ADSL) Optional triple link
b) backup
c) Support 2G/3G/4G/Static IP/DHCP/L2TP, PPTP, PPoE WAN access methods
d) Support VPN client (PPTP, L2TP, OPENVPN, IPSEC and GRE)
e) Support VPN server (PPTP, L2TP, OPENVPN, IPSEC and GRE)
f) Support local and remote firmware upgrade, import and export configure file.
g) Support VLAN, MAC Address clone, PPPoE Server
h) Support WiFi 802.11 b/g/n, AP Client, Adhoc, Repeater Bridge mode
i) WiFi support WEP, WPA, WPA2 encryption and MAC address filter
j) Support multi trigger ways, SMS, ring and data
k) Support link disconnection when timeout
l) Support APN/VPDN
m) Support DHCP server and client, Firewall, NAT, DMZ host, URL block, QoS, Traffic statistics,
n) Real time link speed statistics etc.
o) Full protocol support, TCP/IP, UDP, ICMP, HTTP. Optional SMTP, POP3, OICQ, TELNET, FTP, SNMP, SSHD etc.

Cellular Specification

a) Cellular Module: Industrial Cellular module
b) Standard and Band:
c) Main & Standby Module
d) LTE FDD 2600/2100/1800/900/800MHz, (Band 1/3/7/8/20)
e) 700/1700/2100MHz (Band 2/4/5/13/17/25 optional)
f) LTE TDD 2600/1900/2300MHz (Band 38/39/40). 800 / 1400 / 1800
g) MHz. Band27/61/62 Optional
h) DC-HSPA+/HSPA+/HSDPA/HSUPA/WCDMA /UMTS 2100 / 1900 / 900
i) / 850 / 800 MHz (Band 1, 2, 5, 6, 8)
j) EDGE/GPRS/GSM 900/1800/1900MHz
k) Bandwidth FDD LTE: DL: 100Mbps, UL: 50Mbps
l) TDD LTE: DL: 61Mbps, UL: 18Mbps
m) TX power: <24 dBm
n) RX sensitivity: < -109 dBm

System Availability Requirements

AMR system, subsystems and system components shall be able to meet the following availability requirements. The CDCS software shall have a measured availability of 99.99 % or better during the availability test.

The CDCS software shall continue to operate without interruption under any single point of failure condition. That is, there shall be no hardware or software element whose failure renders the CDCS unavailable. This requirement shall specifically include all AMR system components like hardware, the interconnections among hardware, power supplies, and all enclosures.

Field Wiring: The Tenderer has to provide the following:

Wire: Single core, 2.5 sq. mm, multistrand copper wire along with items like “U” lugs(copper), sleeves, ferrules, necessary terminal blocks etc for PT wiring.

Wire: Single core, 2.5 sq. mm, multistrand copper wire along with items like “Ring” lugs(copper), sleeves, ferrules, necessary terminal blocks etc for CT wiring.

Uninterrupted Power Supply and cable for Meters.

All required items not specifically mentioned but required for successful commissioning of the project.

Laptop Spec: The laptop with OS & Meter reading software shall have at least specifications as mentioned in Annexure-M-I:

System Sizing and Performance Requirements

AMR System shall meet the following system sizing and performance requirements. The system sizing and performance requirements are specified for main subsystem. Standby subsystem shall have the same sizing and performance requirements. The Acceptance of the product shall be based on the Owner/SLDC approved test protocols/ schedules to be submitted in advance by the Tenderer ahead of factory/site inspection. The system sizing for AMR System is only specified for initial sizing. The delivered system shall be expandable as the input and output requirements grow. Vendor is required to demonstrate their system’s expandability in FAT.

CDCS shall be capable to receive data from a minimum 400 DCUs, which is collecting up to 15 energy meters connected per DCU, at the minimum data collection interval. However, CDCS shall have provision to collect and handle data from up to 1000 DCUs and up to 5000 energy meters without any significant degradation of performance.

GENERAL CONDITION: The Tenderer stands responsible for end to end integration from meter output to CDCS. Field Survey for Availability of GPRS-2G 3G/4G data networks may be made by the Tenderer prior to submission of TENDERs.

DRS approval- Data sheet approval (of all items to be supplied, BOQ-item or Non-BOQ item as required to be supplied under project- Refer Note-4 Annex-L, Annex-M-II) along with scheme drawing approval will be proposed by executing agency at the scheme/design engineering stage and will be approved by the utility.

Location wise as built drawing (showing what are items supplied/connected /installed in one location, wiring schedule if any) will be provided by Tenderer after commissioning.

A SAT/Commissioning format (for all items) will be proposed based on the scheme as finalized and same will be followed.

SYSTEM

Network Communication

Users and MDAS applications shall be able to communicate within the ABT system local area network (please refer to the tender “Supply, Installation, Testing and Commissioning of IT Solutions as a part of Scheduling, Accounting, Metering and Settlement of Transactions System at SLDCs in the North Eastern States”)and operate as described in this Specification. The network communications software shall use a standard network protocol such as TCP/IP. The software shall link dissimilar hardware nodes such as workstations, servers, and peripheral devices into a common data communication network allowing communications among these devices.

Remote Diagnostic

Remote Diagnostic facility with necessary Hardware as required shall be provided for communication between the CDCS system at control center, DCU at Sub-station and the utility’s support office for the diagnosis of Hardware & Software problems. The login shall be protected by a user name & password entry. This facility through separate port shall also be extended to the Owner through a separate secure port for remote maintenance.

Network services

The following network services shall be provided for the users of CDCS system within the LAN(please refer to the tender “Supply, Installation, Testing and Commissioning of IT Solutions as a part of Scheduling, Accounting, Metering and Settlement of Transactions System at SLDCs in the North Eastern States”):

(a) File management and transfer of files containing text, data, and graphics information.

(b) Printing management

(c) Backup over LAN

(d) Task-to-task communications to external computers

(e) Remote procedure call

(f) Remote terminal session

System Security& Cyber Security

The Contractor shall document and implement a Cyber Security Policy in line with CERT-In latest guidelines (http://www.cert-in.org.in) to secure the system and the Contractor shall keep updating the Security settings as per the revised guidelines of CERT-In at time to time. Below listed basic strategies shall be followed by the Contractor for making the entire Control Centre immune to Cyber-attacks.

All the Hardware, OS and application software shall be hardened.

Network partition and DMZ through use of Firewall as required maximizing the security of ABT, OA AND MIS System while facilitating access for data and information to all stake holders.

All default user id & passwords shall be changed.

All log in/log out and cable plug in/plug out shall also be logged in the System.

Prevent unauthorized users from reading or writing data or files, executing programs or performing operations without appropriate privileges

Document all user sign on procedure

Record all network traffic for detecting unauthorized activity, unusual activity and attempts to defeat system security (Contractor to propose and document what constitutes normal activity/traffic)

Vendor has to identify and list the entire network and other protocols that communicate with physical systems and limit what is not required.

Network Zoning shall be implemented as per the proposed architecture given in Fig.1. However, the Contractor may suggest other methods of network architecture without compromising the security of the System.

No user shall be allowed to access remote network zones other than the adjacent zone.

Latest Cyber Security Guidelines of CERT-In specified at (http://www.cert-in.org.in) shall be followed.

In normal condition all USB ports of all servers/work stations shall be disabled

Database Management

The database manager shall locate order, retrieve, update, insert, and delete data to ensure database integrity and have provision for backup and recovery of database files. The database manager shall generate and modify all meter data by interfacing with all database structures. In systems with a distributed database, the database manager shall have access to all portions of the database wherever stored. The location of database items shall be transparent to the user performing database maintenance.

All newly defined database pages, elements or data shall be initially presented to the user with default values for all parameters and characteristics where defaults are meaningful. The user shall be guided to enter new data, confirm existing data, and change default values as desired.

All required entries for any database item selected for changes shall be presented to the user. When parameters are entered that require other parameters to be specified, the additional queries, prompts, and display areas required to define the additional parameters shall be presented automatically.

The database manager shall include the mechanisms, in both interactive and batch processing modes, to perform the following functions:

(a) Add, modify, and delete database items.

(b) Add, modify, and delete application program data

(c) Create a new database attribute or new database object

(d) Resize the entire database or a subset of the database

(e) Redefine the structure of any portion of the database.

Database development tools

The Contractor shall provide all necessary software tools for the development and maintenance of the databases at Control Centre. This tool shall be capable of managing the entire system database. The database development software tool delivered with the CDCS/MDAS system shall be used to generate, integrate and test the database. The database development tool shall facilitate IEC 61970 CIM data exchange of both incremental and full power system model.

This tool shall contain database structure (format) definitions and all initialization data to support the generation of all relational and non-relational run-time databases required to implement the system's CDCS/MDAS functions. The tool shall include consistent, coordinated procedures to manage and access the databases. Extensive reasonability, integrity, and referential integrity checks shall be made on user entries to detect errors at the time of entry. Invalid entries, such as entering an invalid data type or attempting to define contradictory characteristics for a database item, shall be detected and reported to the user in an error message. Help displays shall be available to provide additional, detailed information to the user on request.

Tracking Database Changes

The database manager utility shall maintain Audit trail files for all changes made by all users. The audit trails shall identify each change including date and time stamp for each change, and identify the user making the change. An audit trail of last one-year operations shall be maintained.

Cyber Security

The entire system shall be subjected to cyber security audit every year by CERT-IN certified agencies. The Tenderer shall arrange for cyber security audit.

Reporting System

Data Extraction – The incremental Data is to be extracted from the various data sources including web-forms, data files and loaded into the master data store. The extractors to the source and target data sources must be provided as part of the application. It must be feasible to schedule the data extraction activities and perform them on ad hoc basis and pre-defined trigger. The Solution must be able to check for availability of data to be extracted and present the status on a dashboard

Data Validation - Relevant rules are to be defined on the extracted data to validate the reasonability of the information. These include rules for checking the value range, sign, and null values. The solution must enable to define business rules / validation rules on a data element level. It must also list/highlight pending data inputs for completion of a process.

Data Store - The validated data shall be loaded into a data store using an appropriate tool. The data to be loaded must be transformed, cleansed, and standardized before loading into the data store. The business rules defined by successful Tenderer shall be validated by the utility. The database shall eventually be hosted on the Storage Area Network (SAN) (please refer to the tender “Supply, Installation, Testing and Commissioning of IT Solutions as a part of Scheduling, Accounting, Metering and Settlement of Transactions System at SLDCs in the North Eastern States”)for scalability and ease of archival. The application must be able to interface with SAN. Tools for DB archival, truncation etc. to be provided as part of the Application

Reporting - The data in the data store shall be used to generate reports that involve arithmetical and statistical operations on the data to arrive at calculated values. The reports to be generated include the current set of reports. Report generation in multiple file formats like XLS, PDF etc. must be supported. The solution must enable drill down, drill across and roll-up for data elements Design and publish new reports on a need-based basis. Create dashboards, charts & reports

User Friendly Graphical user Interface (GUI) for editing report formats, layout field’s etc. facility to augment an existing report with copy-create options to incorporate changes from time to time.

- The different types of reports to be generated are
- Regular reports on trigger after all data is uploaded
- Custom report
- Freeform nullified query interface (User shall be able to select fields/parameters dynamically and generate the report)

The GUI for making new reports and custom reports must be use friendly with DB field appearing on a pane which could be dragged and dropped at a relevant location on the report. The solution shall also provide a web form for entry of data for creating a log book type report at the end of every shift, outlining brief details of events during the shift-outages in shift, LCs availed etc. the reporting solution shall also be required to output data in csv, xls(x) format for aiding in preparation of weekly, monthly and yearly report. These reports are available in SLDC websites.

Configurability - The reporting requirements are dynamic and new reporting needs arise from time to time. The underlying data for the reports shall still be available in the system but the system shall be configurable to generate administrator defined reports and publish them. The solution shall be future ready to accept newer sources of data through ODBC, XML, CSV, TXT and generate fresh reports applying of varying periodicity.

Dashboards - The reporting needs include generation of reports in easy to use and intuitive graphical format allowing the selection of widgets, chart types, flash objects and features such as tool tips. Data querying shall be enable for all authenticated users from SLDC to the master database at RLDC/NLDC as part of custom report or free from query.

Data Replication - The Schema of the data store at each of the SLDC needs to be replicated at RLDC/NLDCs on real time basis. At the RLDC a separate set of reports need to be published aggregating the data of all the SLDC’s own data Suitable solution architecture is also shown below for the application and data base server deployment

Administration - Separate groups of users shall be created to access the systems like System Administrator, SLDC Administrator, SLDC Member, User Member, Public. Different user categories and their functionalities to be decided by respective SLDCs.

Notifications - The solution must support notifications through SMS and e-mail. SMS and email gateways/ API (SMS) shall be provided by SLDC. Notifications to the relevant users upon submission, updating and non-submission of data (beyond threshold time) shall be some of the applicable scenarios.

Solution Access - The Solution must be accessible securely both from within the SLDC Intranet and the Internet. All forms, page for upload of data etc. exposed to Internet for constituents /ISGS data entry has to be password protected.

General Requirement:

Software’s shall be Web based application developed in open-source technology; all the additional plugin / server software licensing cost shall be included in scope and taken care by the Tenderer.

The software shall have role base access.

The software shall have authentication and authorization with single sign–on.

The integrated operation software shall be user friendly, scalable etc. Some of the features of the application are as:

- All logs should be highlighted with a notification.
- Pointer duplicacy should be avoided while making data base.
- Uniformity/Standard should be maintained for all data base.

Nomenclature/ Aliases should be decided by the supplier and SLDC/utility.

- Common front end for all the modules
- Integration of all the modules with each other
- Integration of any other related third party application in the common front end.
- Upgrading the modules as per extant and amended regulations of CERC/SERC.
- Output of all these modules should be configured with the other modules of SAMAST.

- The software shall be designed in extensible manner so that it can accommodate future changes and could be easily maintained.
- The software shall have facility to add/block/edit users having different levels of rights and authorizations.
- The software design shall take care of system performance tuning & other configuration details as may be required.
- The software shall prompt alerts and /or confirmation before any major changes like marking for deletion, updating etc.
- Software shall have usual GUI and operating aids like Troubleshooting Tips, Keyboard Shortcuts, Tool Tips, Menu and Toolbar, that are not conflicting with the end user browser settings.
- The software shall have compatibility with industry standard internet browsers such as Microsoft Internet Explorer, Mozilla Firefox and Google Chrome etc.
- There shall be facility for import / export of data through Excel sheet / Open office spread sheet/csv files.
- Option for exporting reports to PDF and excel / csv formats.
- Suitable scheduling of back-up (application and database) through the application/automatically as per the requirement of data security.
- The developed software shall have the facility to register requirement/ modification and bugs reported by various users during operation.
- The system developed shall have facility of help by way of FAQs and User Documentation to the users of the system.
- The software shall have provision for sending auto-generated e-mails/SMS, as identified by the system administrator.
- The software shall maintain the version details and changes carried out in respective version. These details shall be available to all users.

Audit: The system shall provide defined audit trail of various activities performed by the users as required.

CHAPTER 31: TECHNICAL SPECIFICATIONS OF POST INSULATORS

31.1 The post insulators shall conform in general to latest IS: 2544, IEC-60168, IEC60273 and IEC-60815.

31.2 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.,,, **Conical design insulator shall not be accepted**.

31.3 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.

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

31.5 All ferrous parts shall be hot dip galvanised in accordance with the latest edition of IS: 2633, & IS: 2629. The zinc used for galvanising shall be grade Zn 99.95 as per IS: 209. The zinc coating shall be uniform, adherent, smooth, reasonably bright, continuous and free from imperfections such as flux ash, rust stains, bulk white deposits and blisters. The metal parts shall not produce any noise generating corona under the operating conditions.

Sl. No	**Parameters**	**400 kV**	**220 kV**	**132 kV**	**33 KV**
1	Type	Solid Core	Solid Core	Solid Core	Solid Core
2	Highest system voltage	420 kV	245 kV	145 kV	36 kV
3	Dry one minute power frequency test voltage	680 kV	510 kV	275 kV	75 kV
4	Dry Impulse voltage withstand test	1425 kV	1050 kV	650 kV	170 kV
5	Wet switching surge withstand voltage (kVp)	±1050	-	-	-
5	Minimum Creepage Distance	13020 mm	7595 mm	4495 mm	1116 mm
6	Minimum Bending Strength (upright)	10 kN	8 kN	6- kN	4-kN

Chapter 32:Technical Specification for Sub-Station Surveillance System

1.0 General

The specification covers design, supply, erection, testing and commissioning of the complete surveillance system including cameras, Network Digital video recorder, computer with peripherals, mounting arrangement for cameras, cables etc. for effective visual monitoring of total Sub-Station premises.

The number of cameras and their locations shall be decided to monitor at least:

- **All the Transformer and Reactors**
- The operation of each and every isolator of the complete yard.
- All other Major Equipments (such as CB,CT,CVT, SA etc.)
- Key areas of control room cum administrative building, Indoor switch gear room, entire GIS Hall, Relay room etc.
- All the Entrance doors of Control Room Building, Fire-fighting Pump House, GIS Hall, Sub-Station main gate, gates of switch yard, colony entrance gate etc.

The cameras can be mounted on structures, buildings or any other suitable arrangement to be provided by the contractor.

2.0 Technical requirements

The system shall use video signals from various types of indoor/outdoor CCD colour cameras installed at different locations, process them for viewing on workstations/monitors in the control Room and simultaneously record all the cameras after compression using H.264 or better standard and streamed over the IP network. Mouse-Key board controllers shall be used for Pan, Tilt, Zoom, and other functions of desired cameras. The System shall provide sufficient storage of all the camera recordings for a period of 45 days or more @ 25FPS, at 4 CIF or better quality using necessary compression techniques. It shall be ensured that data once recorded shall not be altered by any means. The recording resolution and frame rate for each camera shall be user programmable. The provision for transfer of recorded data to separate external media shall be ensured.

The surveillance CCTV System shall operate on 230V, 50Hz single-phase power supply.

3.0 System requirements:

a). Camera with external encoder shall be used for image capture.

b). Indoor cameras shall be either with fixed focal length lens or with Pan/Tilt & Zoom lens as per site requirement. All outdoor Cameras shall be Day/Night PTZ Dome type cameras.

c). Housing of cameras meant for indoor use shall be of IP 42 rating whereas outdoor camera housing shall be of IP 66 or better rating.

d). 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.

e). System to have facility of additional camera installation beyond the originally planned capacity.

f). System shall be triplex i.e., it should provide facility of simultaneous recording, playback & network operation.

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

h). System shall have provision for remote monitoring.

The equipment should generally conform to Electromagnetic compatibility requirements for outdoor equipment in EHV switchyards. Type test reports to establish compliance with this requirement shall be submitted during detailed engineering.

4) VIDEO SURVEILLANCE APPLICATION SOFTWARE

- **a)** Digital video surveillance control software should be capable to display and manage the entire surveillance system. It should be capable of supporting variety of devices such as cameras, video encoder, Servers, NAS boxes/Raid back up device etc.
- **b)** Surveillance control software should be compatible with MS Windows operating system.
- **c)** The software should have inbuilt facility to store configuration of encoders and cameras.
- **d)** The software should Support flexible 1/2/4/8/16/32 or more Windows Split screen display mode or scroll mode on the PC monitor.
- **e)** The software should be able to control all cameras i.e., PTZ control, Iris control, auto /Manual focus, and color balance of camera, Selection of presets, Video tour selection etc.
- **f)** There must be a single encoder for each camera.
- **g)** The software should have user access authority configurable on per device or per device group basis. The user shall have the facility to request the access and control of any camera for a pre-determined time period. Control of camera shall be released automatically after expiry of the pre-determined time period.
- **h)** The system shall provide user activity log with user ID, timestamp, action performed, etc.
- **i)** The users should be on a hierarchical basis as assigned by the administrator. The higher priority person can take control of cameras, which are already being controlled by a lower priority user.

j) It should have recording modes viz. continuous, manual, or programmed modes on date, time and camera-wise. All modes should be disabled and enabled using scheduled configuration. It should also be possible to search and replay the recorded images on date, time and camera-wise. It should provide onscreen controls for remote operation of PTZ cameras. It should have the facility for scheduled recording. Different recording speeds (fps) and resolution for each recording mode for each camera should be possible.

k) The software for clients should also be working on a browser-based system for remote users. This will allow any authorized user to display the video of any desired camera on the monitor with full PTZ and associated controls.

l) Retrieval: The VMS application should allow retrieval of data instantaneously or any date/time interval chosen through search functionality of the application software. In case data is older than 45 days and available, the retrieval should be possible. The system should also allow for backup of specific data on any drives like DVD's or any other device in a format which can be replayed through a standard PC based software. Log of any such activity should be maintained by the system.

m) The system shall have backup 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 3 hours. The bidder shall submit the sizing calculation of the UPS considering the total load requirement of the visual monitoring system.

5). Degital Network video recorder

The Personal Computer based Network Video recorder is to be provided. The personal computer shall be of equipped with the following.

- Coloured Laser printer, Internal DVD writer, External USB DVD writer.
- Windows Prof. operating system latest version with license.

1.	Manufacturer	HP/ Dell or better
2.	Processor	Intel Xeon Quad core processor
3.	CPU Clock speed	3.1GHz or better
4.	Cache	8MB Level 3
5.	Chipset	Intel
6.	RAM	8GB: 2133MHz DDR4 RDIMM ECC
7.	Hard Disk	36TB
8.	Storage drive	DVD R/W Drive
9.	Support	Both IPV4 & IPV6

10.	I/O PORTS	1 x serial port, 1 x graphics
11.	USB port	Minimum USB port – 2
12.	Ethernet port	Ethernet 10/100/1000 Mbps
13	Graphics card	NVIDIA 4GB graphics card or better
14	Power supply	230V AC
15	Operating temperature	10 deg C to 55 deg C
16.	Relative humidity	10 – 95%
17	Raid	Raid 5
18	Number of video inputs	32 inputs or more (as per requirement)
19.	Audio recording capacity	32 inputs or more (as per requirement)

Workstation with Monitor:

1.	Manufacturer	HP/ Dell or better
2.	Processor	Intel i7 quad core processor (11th gen)
3.	CPU Clock speed	3.1GHz or better
4	RAM	8GB
5	Hard Disk	2 TB SSD
6	Chipset	Intel
7.	Keyboard	USB standard keyboard 104 keys or better
8	Mouse	USB standard Mouse
9	LAN Card	Ethernet 10/100/1000 Mbps
10	Graphics card	NVIDIA 4GB graphics card or better
11	Power supply	230V AC
12	USB Port	Minimum 2 ports
13	Monitor	32” coloured monitor with VGA/HDMI port
14	Operating system	Latest Windows professional licensed. (should be VMS compatible)
15	Anti virus	Licensed Anti virus shall be provided

6) Camera for Visual Monitoring System (VMS)

The VMS camera shall be suitable for wall mounting, ceiling mounting, pole mounting and switch yard structure mounting. All accessories required for the mounting shall be provided. The VMS camera should be color high resolution, super HAD (Hole-accumulation Diode), Weather proof, Dome type. The Camera shall have an internal amplifier that applies gain to the signal. The amplifier must operate when there is insufficient light in the scene to produce an acceptable video output level, and must only apply as much gain as is necessary. The camera shall incorporate one level of automatic gain Compensation (AGC), allowing the user to achieve the optimal balance of noise and low light performance in demanding environments.

1.	Resolution (TV lines)	1080 horizontal TV lines (Minimum)
2.	Effective Pixels(minimum)	(PAL)1920 x 1080 pixels
3.	Low Light Sensitivity (lux)	0.1lux (Colour); 0.05 lux (B/W)
4.	Signal to noise Ratio	More than 45dB (AGC off)
5.	White Balance Control (WBC)	Adjustable/Automatic(2,100°~8,000°K)
6.	Gamma Correction	d=0.45

Specification for Fixed Dome Camera (Indoor)

The High-Resolution DSP Color Dome Camera (Digital Signal Processing using a DSP chip) shall include, as a minimum, the following features/functions/specifications:

a) The High-Resolution DSP Color Dome Camera shall incorporate a 1/3-inch Charge-coupled device (CCD).

b) The Dome Camera shall support the use of Auto Iris/ Direct Drive lens connected to the camera via 4-pin molex socket located from the inside of the camera housing. The camera must provide power to the lens.

c) The Camera shall support the use of Fixed lens, focal length is 3.6mm, each.

d) The power consumption of the High-Resolution DSP Color Mini Dome Camera shall be no

more than 1watt.

e) Power supply shall be through POE. The camera shall be compliant to ONVIF standards.

f) Enclosure shall be IP42 and NEMA-4X rated.

Specification for PTZ camera–(Outdoor: In switchyard, building terraces)

1.	Electronic Shutter	1/60~1/100,000sec.automatic
2.	Back Light Compensation	Adjustable/Automatic and built-in
3.	Automatic Gain Control	Automatic([0 ~30dB]/41)dB and built-in

	(AGC)	
4.	Lens	360x(30xoptical/12xdigital)IR-corrected Aspherical power zoom lens
5.	Lens Aperture	F1.6~4.7
6.	Pan/Tilt/Zoom Protocol Languages Supported	Yes
7.	Panning Range	Complete 360 degrees(horizontal)
8.	Pan Speed	Adjustable
9.	Tilting Range	180degrees(vertical)
10.	Tilt Speed	Adjustable
11	Effective Pixel	(PAL): 1920 x 1080
12.	Video streams	Dual stream: Primary stream: H.264; Secondary stream: H.264
13.	Supported Protocols	TCP, IP (IPv4 & IPv6 compliant), NTP, UDP, Multicast (IGMP)
14	Security	Multi user access with password protection
15	Preset accuracy	+0.1 deg or better
16	FPS	FPS should be selectable; three setting between 1-10FPS and at least two setting between 10-25 FPS
17	Working temperature	-10 degC to +55 deg C
18	Working humidity	10 – 100% RH (condensing)
19	Power supply	Camera should be powered through suitable POE supply of same camera OEM only.

PTZ-Control–

The features of PTZ shall include:

- Fully functional dynamic keyboard controllers with joy stick for smooth camera movements. It should control upto 255 units from a single keyboard.
- Controls all pan, tilt and zoom functions
- Keyboard shall be compatible with all connected cameras.
- The cameras shall be pure IP and the camera shall be compliant to ONVIF standards
- The cameras must be of Day and Night type.
- The cameras must be operative in automatic mode for switching from day mode to night mode depending on the ambient natural light intensity without having to manually operate.

- It shall be possible to define at least 128 selectable preset locations per camera so that the camera gets automatically focused on selection of the location for viewing a predefined location. It should be possible to name each of the preset position using at least 16 alphanumerical characters.

- Each camera shall have an inbuilt memory for backup of configuration/ time information when camera is powered off.

- The camera features must be quickly and easily accessible by provision of on-screen displays.

- The camera shall have temper proof feature, i.e., it shall inform the operator of any change in its placement, blocking of the view etc.

- The camera shall have advance tour programming feature. It shall store ‘Tour’ feature,

i.e. perform a pre-configured PTZ movement and record the video during this movement. When the operator takes control of the camera, the camera shall move as per the operator’s direction and return to the ‘Tour’ after a pre-configured amount of time. Minimum 2 tour per camera.

- The camera shall have shock detection, auto tracking and motion detection feature.

- Other features of the camera shall include remote firmware updates, secure backup of all camera settings, password protection to prevent unauthorized users from altering system settings.

- The cameras shall have IP-66, IK10, NEMA 4X-rated enclosures. Enclosure shall have provision to avoid fogging during high humidity condition & camera shall be able to perform satisfactorily.

- The camera communication port shall be interfaced with a media converter / ethernet switch to be provided in a junction box / rack.

- Camera mounting / clamp size shall be robust enough to ensure no vibration which can affect the quality of video particularly at highest zoom level.

- The power supply / POE supply to camera and the media converter shall accept power at 230V AC with +- 10% variations and 50Hz frequency +- 5% variations and meet the power supply requirement of camera & media converter as per manufacturer’s recommendation.

Specification of IP outdoor bullet camera (Main Gates)

1.	Electronic Shutter	1/1~1/100,00sec.automatic
2.	Min Luminous	0.1 Lux(Color); 0.05 Lux(B/W)
3.	Bandwidth control	Yes
4.	Lens	20x or better

5	Wide dynamic range	120dB or better
6	Effective Pixel	(PAL): 1920 x 1080
7	Video streams	Dual stream: Primary stream: H.264; Secondary stream: H.264
8	Supported Protocols	TCP, IP (IPv4 & IPv6 compliant), NTP, UDP, Multicast (IGMP)
9	Security	Multi user access with password protection
10	Preset accuracy	+0.1 deg or better
11	FPS	1-25 FPS
12	Working temperature	-10 degC to +55 deg C
13	Working humidity	10 – 100% RH (condensing)
14	Power supply	Camera should be powered through suitable POE supply of same camera OEM only.
15	ONVIF compliant	Yes
16	Enclosures	IP66 and NEMA -4X rated enclosures.

EMI/EMC requirements: The equipments should generally conform to EMC requirements for outdoor equipment in EHV switchyards. The major EMC required for cameras and other equipment shall be as under:

1) Electrical fast transient (Level 4) as per IEC 61000-4-4

2) Damped oscillatory (1 MHz and 100KHz) (level 3) as per IEC 61000-4-18

3) Electrostatic discharge (Level 4) as per IEC 61000-4-2

4) Power Frequency Magnetic field (Level 4) as per IEC 61000-4-8

5) Ripple on DC Power supply (Level 4) as per IEC 61000-4-17

AC voltage dips & interruption / variation (Class 3) as per IEC

Chapter 33: IP Base PA system

GENERAL

1.0 The scope of this specification covers engineering, design, manufacturing, assembling, inspection & testing at works, packing, supply, delivery, unloading and handling at site of Public Address System for efficient and trouble-free operation after installing the same at site.

2.0 Engineering: The “Engineering” shall broadly cover the detailed design of PA System as per the requirements of this specification, selection of equipment, materials, estimation of quantities etc. and preparation of all drawings necessary for the erection of the system. Complete engineering shall be as per the guidelines of purchaser and shall be subject to the approval.

3.0 It is not the intent to specify complete details of design and construction of equipment. However, the equipment shall conform in all respects to acceptable standards of design, engineering and workmanship and shall be capable of performing satisfactorily in continuous commercial operation under the specified environmental condition in a manner acceptable to purchaser, who shall be entitled to reject any work or materials, which in his opinion is not in conformity with the duty requirements.

4.0 Review of the bidder’s documents by the purchaser shall not relieve the bidder from his responsibility for the design and supply as per requirement of technical specification.

5.0 The Bidder shall guarantee satisfactory performance of the equipment under stipulated variations of voltage and frequency. The design and manufacture shall be such that equipments/components of same type and rating shall be interchangeable.

2.0 CODES AND STANDARDS

2.1 The equipment covered under this specification shall be designed, constructed and tested in accordance with this specification and latest revisions of applicable Indian Standards (IS), IEC and other internationally recognized standard and local laws & regulations applicable to the project except where modified and/or supplemented by this specification. Mandatory regulations cannot be superseded by this specification.

2.2 The equipments furnished under this specification shall conform to the latest issues and most recent revisions & amendments of the following non-exhaustive list of standards.

- ANSI : American National Standards Institute
- BS : British Standards
- CCITT : Consutative Committee on Telephone and Telegraph
- EIA : Electronics Industry Association
- FM : Factory Mutual
- IEC : International Electrotechnical Commission
- IEEE : Institute of Electrical and Electronic Engineering
- IS : Indian Standard
- ISA : Instrument Society of America
- ISO : International Standards Organization
- ITU : International Telecommunication Union
- NEC : National Electrical code

- NEMA : National Electrical Manufacturers Association

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

- ANSI S3.5 Methods for the Calculation of the Speech Intelligibility Index

BRITISH STANDARDS (BS)

- BS EN 60268-5: 2003 Sound system equipment, Loudspeakers.
- BS EN 6840-13: 1998 Sound system equipment. Listening tests on Loudspeakers.
- BS 6840-14: 1987 Sound system equipment.
  Guide for circular and elliptical Loudspeakers;
  outer fram diameters and mounting
  dimensions.
- BS 8473 :2006+A1:2008 Intruder and hold-up alarm systems. Management of false alarms. Code of practice.

INDIAN STANDARD (IS)

- IS-5 Colour for ready mixed paints and enamels.
- IS-694 PVC insulated cables for working voltages up to and including1100 V.
- IS-1554 PVC insulated electric cables.
- IS-2147 Degree of protection provided by enclosures for low voltage switchgear and control gear.
- IS-3961 Recommended current ratings for cables.
- IS-3975 Mild steel wires, formed wires and tapes for armoring of cables.
- IS-5831 PVC insulation and sheath of electric cables.
- IS-7741 Specification for Loudspeakers.
- IS-8130 Conductors for insulated electric cables and flexible cords.
- IS-9302 Characteristics and methods of measurements for sound system equipment.
- IS-9537 Conduits for electrical installations.
- IS-10426 Specification for public address amplifiers.
- IS-10918 Vented type nickel cadmium batteries.

INTERNATIONAL ELECTROTECHNICAL COMMISSION (IEC)

- IEC 60268-5 Ed.3.1 en:2007 Sound System Equipment – Part 5: Loudspeakers.
- IEC 60529 Classification of Degrees of Protection Provided by Enclosures (IP Code)
- IEC 60839-5-2 ed. 1.0 b:1991 Alarm Systems Part 5
  Requirements for alarm transmission systems.
- IEC 61000 (All Parts) Electromagnetic Compatibility (EMC)

The system shall be adequately protected from signal and power line noise and meet the Surge Withstand Capability (SWC) requirements of ANSI C37.90 A/IEEE standard 472-1989 equivalent.

3.0 SCOPE OF WORK

Bidder shall be fully responsible for both the products and their relevant compliance with the requirements of the specification.
Provisions included in the specification will not be limitative to the scope of work. Bidder shall provide for any further activities which will improve the quality & performance of the system offered.

3.1 INCLUSION IN SUPPLY

Bidder's scope of supply shall include but shall not be limited to following:

(i) Plant IP Based Public Address & Paging System with all accessories specified herein and other Technical Attachment Sheets.

(ii) Development, supply & installation of required software for the total system.
(iii) Uninterruptible Power Supply System to cater to the entire system load.
(iv) Associated copper, Cat6 and fibre optic cable for interconnection.
(v) Recommended spares for the entire system trouble free operation.
(vi) Erection & commissioning spares
(vii) Special Tools & Tackle and test equipment.
(viii) The items not mentioned but required for successful completion and guarantee run of the project
/ System including modification, addition in existing system shall be in the scope of the bidder.

3.2 SCOPE OF SERVICE

Following service shall be provided by Bidder for equipment & systems supplied under this specification. However, Bidder has to provide the services required for completeness and correctness of the system irrespective of whether it is mentioned in the specification or not.

(i) Manufacture of all items as per requirement of specification, assembly etc.
(ii) System Engineering, development of software etc.
(iii) Furnishing drawings, documents, data sheets, manuals/catalogs as specified.
(iv) Inspection and testing at Bidder's works as per the Quality Assurance Plan.
(v) Packing and forwarding of all equipment included under this specification.
(vi) Establish the specified interfaces and demonstrate operation.
(vii) Site modification and preparation of "as-built" documentation".

4.0 DESIGN REQUIREMENTS (CONCEPTUAL VIEW)

The PA System shall be designed as standalone IP based network architecture. The system shall be based on centralized control together with distributed nodes permitting speech broadcasts and pre- recorded messages/ alarm tones etc. The carrier system shall be based on Voice over IP to provide IP communication across the complete PA system.

The System offered shall be minimum 2-Channel Page & Party configuration with various area-wise zone stations forming functional groups comprising Field Call Stations and Loudspeakers. The Field Call Stations & Standalone amplifiers shall be IP addressable whereas speakers shall be of analog type without IP Address. Any conversion of analog field call station to IP mode by separate attachment of the intelligent module/ unit shall not be acceptable. The field call stations shall have additional amplifier to drive additional one speaker.

The distributed nodes shall be interconnected through OFC based network. The PA system shall be designed such that no single failure shall disrupt the availability of the complete system. A redundant server will cater to all zones of the plant. However,both the server shall be located at control room.

Each node location shall be equipped with a Field Ethernet Distribution Switch and shall also be equipped with PA remote interface equipped switching technology which form part of the in-plant paging and PA remote node.
The speakers, FCS shall be connected to their respective PA controller (Central Exchange) through fiber optic cable network. The structure of the fiber optic cable backbone, field ethernet switches, number of master call stations etc. may be subject to changes during detail engineering stage. The different types of speakers and Call Stations shall be deployed over locations around each of the nodes (Ethernet switch).
In noisy areas shall be used along with acoustic booth. The speakers and FCS in each zone shall be connected through Star fashion to the respective Ethernet switch by CAT-6.

The system will be installed in an adverse industrial environment. Equipment in some areas will be subject to vibration, dust, oil/water vapors as prevalent in thermal generating plant. The design shall be such as to provide highly intelligible minimum two-channel voice communication even in areas of high background noise (50 db to 100 db).

Equipment shall be self-protecting against transients in the input A.C supply and against failure of any component or cable in the entire communication system.

Required functions for individual stations shall be programmable and configurable through pre-loaded software that permits local changes to the configuration. Levels of system access and privileges shall only be assignable to selected individuals. Configuration of the system shall be achieved by user friendly based
software for maximum flexibility, easy re-configuration, maintenance and future expansion which enables an operator to implement speed commissioning and also carry out routine diagnostic checks/ fault finding functions of PA System components. It should be possible to make adjustments when the system is installed without resulting in modification to the system wiring. The system shall be provided with standard serial interface (preferably a USB connection) to be connected with a laptop for local and remote access for maintenance and operations activities. One Notebook PC shall be provided for these functions.

Speaker cabling and visual alert cabling shall be on a ring to provide resilience.

The plant area shall be divided into zones each with sections. Final distribution of units over the zones will be finalized during detailed design. This will be related to area configuration and other operational objectives.
Some PA and Industrial Talkback field call station units may be located in areas with a fair degree of background noise. Therefore, the requirements shall be for directional dynamic microphones, with strong noise suppression together with input/pre-amplifier sections including filtering and speech compression giving the highest practicable levels of intelligibility.

Each operator's control set will be able to:
a) Address a call to one or multiple sections.
b) Address a call to one or multiple zones, by activating the selected zones.
c) Transmit a general call to the whole area activating all sections simultaneously.

The system shall also provide the following facilities:
Any field call station can selectively dial any other call station from its inbuilt dialling pad without the manual intervention of any zonal operator. The intelligence Unit dialling button/keypad etc shall be an integral part of the call station and shall not be procured form different OEMs and combined.

The system shall be capable of providing an audio output to a Digital Voice Recording System.
This unit is used, as above, to gain access to the PA system by telephone or radio, but the message to be broadcast is digitally stored and played through the DVSP monitor speaker on the Engineers Test Panel, this allows the engineer to intercept calls which he does not think are suitable for broadcast.

The DVSP shall record calls that cannot be sent to all required zones because some are occupied by a higher priority call. The unit shall store up to minimum 15 calls in high quality format with a maximum of three minutes for each call, including chimes and pre-recorded messages. Playback of a call can start while it is still being recorded. The unit can record and/or playback up to minimum eight calls simultaneously.
CD audio player shall be provided as one of the input/output sources to/from the public address system which shall have the capability to broadcast the player output.

An interface to the telephone system shall be provided to enable users to broadcast routine speech announcements from telephones assigned the correct class-of-service. The system interface to the telephone system shall be via a 2- wire/4-wire E & M tie-line/E1 line /SIP channel. Facilities shall be included to prevent acoustic feedback that may be generated from telephones situated close to loud- speakers.

The system shall be fitted with devices to enable and affect frequency shifting of voice input during PABX radio access. Acoustic feedback via telephone or radio connection to the PA/alarm system can only be totally eliminated by the use of a digital voice storage/play-back (DVSP) unit.

Power Supply to PA System and allied accessories shall be provided from local UPS. The local UPS shall be in Bidder’s scope of supply. Power points (240V AC supply) for charging of local UPS for PA System and allied accessories shall be provided by the Owner within 3 Meters (wherever possible) of the point of location of the local UPS. Bidder shall also provide local power distribution boxes (if required) for sub distribution of supply from local UPS to call stations and amplifiers. Location of local UPS & power distribution scheme shall be finalized during detailed engineering.

All the main elements in PA and Industrial Talkback system viz. Controller, field call stations, DTS, MCS, speaker shall be sourced from the same OEM.

The software shall be “user Friendly”, for easy re-configuration, maintenance and future expansions. All software utilized shall be the latest and upgraded version. The software shall be able to work with the latest windows version.

“The system shall be designed to comply with EMI and RFI Regulations particularly the requirements of IEC 61000 series.”

The system shall also have the following functional features:

1. Configuration of Announcement Priorities
   Announcements from different sources can be configured to override others. Fixed frequency preannouncement tones can be generated under software control.

2. Gain Control of Announcements
   Announcements shall be individually configurable to different levels. This is a useful feature which allows an alarm to be muted while a broadcast is made and then increased back to its original level afterwards.

3. Speaker/ Line Monitoring
   a) The system shall provide the facility for monitoring speaker loop status. Automatic setting procedures shall be able to be programmed in order to check and set all output line conditions.
   b) Difference above a set percentage will result in an alarm indication on the control mimic panel.

The design of panels, cabinets, enclosures and packaging density of components mounted therein shall be such that the temperature rise does not exceed 100 C above the ambient under the worst conditions

5.0 SYSTEM DESIGN ENGINEERING

5.1 ENGINEERING INPUTS: Complete engineering shall be done by the vendor on the basis of following documents to be furnished by purchaser:

a) Area wise allocation of field call stations & loudspeakers and their type.
b) Layout drawings of areas.

5.2 ENGINEERING OUTPUTS: Vendor shall prepare and submit following documents and drawings for purchaser's approval:

a) Technical write-up (system Description).
b) Bill of quantities for all items.
c) GA drawing cum technical datasheet of all the equipments.
d) Mounting arrangement drawings.
e) Interconnection diagram showing the interconnection among all the PA System equipments/ allied accessories and also covering the sizes of cable.
f) Conductor sizes of cables and wires with voltage drop calculations.
g) Cable schedule.
h) Testing and commissioning guidelines
i) O& M Manuals
j) Type test report
k) Test procedure if required

6.0 CONSTRUCTIONAL FEATURES

Public Address system shall comprise of PA system controller, network switches, media converters, Call stations, master control stations, amplifier and loud speakers, associated cabling. Details of each of these and other items required to make the system complete are furnished below.

6.1 PA SYSTEM CONTROLLER (SERVER)

The server shall be based on state of art VOIP technology. The server should support protocols including SIP or equivalent, TCP, IPV4/IPV6, Codec G 722, SNMP, RTP, NTP etc. Suitable built in IP security such as firewall, SSH, HTTPS etc. shall be provided in server. The server should be able to support the required number of call stations with future provision. The required no. of all hardware/ software licenses to meet the specifications shall be supplied by the contractor.
The server shall be capable of self-recovery in case of any fault/network break down. It shall be rack mounted type. The server shall be able to support minimum 4 channels for GSM communication with PA system. Suitable interface for the same shall be provided by the bidder. All programming tools & Software that are required to program/reprogram the system shall also be provided along with the server. The system functions may be programmed from a variety of external and/or internal sources such as via the connection to a Notebook PC.

The control sub-system and their ancillary devices shall be housed in a standard rack mounted system cabinet with all control, power circuits and necessary amplifiers and shall be supplied in pre-wired conditioned and shall be completely tested at manufacturer's works prior to dispatch.

6.2 DISTRIBUTED AMPLIFYING SYSTEM

Each call station shall have its own preamplifier, line amplifiers (wherever required, shall be provided for long line signal transmission) and power amplifiers to suit its loudspeaker capacity. The system shall be as below:

(i) The amplifiers shall be heavy-duty type.
(ii) The amplifiers shall be of solid-state electronic type and compact in construction.
(iii) The amplifiers shall be solid state class D push pull type, in built with the call station fully conforming to applicable Indian standard.
(iv) Amplifier shall have 0-100% volume control facility for coarse and fine setting, input sensitivity control, receiver volume control, bass cut filter and anti-side tone control feature.
(v) Pre-amplifying stages shall be furnished to make it suitable for operation with low level input such as microphone.
(vi) Suitable arrangement shall be provided for amplifiers as well as preamplifier, to cut down the power requirement during standby or idling time in order to minimize open line hum as well as unnecessary loss of power.

6.2.1 Standalone amplifier

Amplifiers of suitable rating shall be provided for general announcement. Multiple loudspeakers spread across a zone shall be used along with a standalone amplifier in the field/centralised amplifier. This amplifier shall be IP based and health monitoring of associated loudspeaker shall be provided.

6.3 CALL STATIONS

The following type of call stations shall be offered:

a) Type A-Desk mounted master type (Overall master station & zone master station)
b) Type B-Desk mounted indoor type
c) Type C-Wall/ Column mounted indoor/outdoor type
d) Type D-Wall/ Column mounted explosion proof type
e) Type E- Portable type

6.3.1 Type A-Desk mounted Master Station (Overall master station and zone master station):

A directional gooseneck microphone shall form part of each control set. When the microphone shall be use, nearby loudspeakers shall be muted to avoid acoustic feedback. The microphone amplifier shall be fitted with an automatic gain control for convenience in use.
Each master station (overall/zone) shall be equipped as minimum with the following:

a) A magnet dynamic, gooseneck microphone and a telephone handset with automatic switch from the microphone to the handset upon lifting the last one.
b) Necessary lamps, push buttons, switches, and indicators to monitor and control the system.

6.3.1.1 Constructional Features of overall master control station are as follows:

(i) Desk-top, Indoor, air-conditioned
(ii) Microphone: Gooseneck
(iii) Enclosure: Anodized aluminum/ fibre glass reinforced polyester/high impact polycarbonate/stainless steel/ polyurethane or any other material subject to prior approval of purchaser
(iv) Zone selection: Dedicated buttons
(v) Emergency features: One touch/one push button paging, caller ID, Speed dialing

6.3.1.2 Constructional Features of zone master station are as follows:

(i) Hands-free, desk top, dual direct.
(ii) Location: Indoor
(iii) Protection: Corrosion resistant & pilfer proof.
(iv) Protection Class: IP 32
(v) Body: Anodized aluminium/ fibre glass reinforced polyester/high impact polycarbonate/stainless steel/ polyurethane or any other material subject to prior approval of purchaser
(vi) Microphone Type: Gooseneck
(vii) Volume Control shall be provided.
(viii) Loudspeaker output: Yes

6.3.2 Type B-Desk mounted indoor station

Constructional Features of desk top mounted indoor station are as follows:

(i) Material: Die cast aluminum/ fibre glass reinforced polyester /polyurethane/high impact polycarbonate/ stainless steel or any other material subject to prior approval of purchaser
(ii) Integrated full range speaker

(iii) All keys with individual labelling area
(iv) Call or busy signal by light emitting diodes
(v) Noise cancelling goose neck microphone with dynamic compression
(vi) Microphone sensitivity and loudspeaker volume control
(vii) Potential free relay contact
(viii) Frequency range: 300 Hz to 7 khz
(ix) Amplifier power rating: 1 W
(x) Loudspeaker: 5Watt
(xi) Electrical data booster amplifier - output power - 25 W
(xii) Operating Temperature: 0° to +55° C
(xiii) Protection class: IP30 or better

6.3.3 <u>Type C-Wall/ Column mounted indoor/outdoor station:</u>

All call stations have a compact, robust, rust resistant, shock resistant body. The outdoor wall/ column mounted call stations shall be tamperproof, using internal anchoring bolts and peculiar (e.g., triangular head, counter sunk) screws which can be loosened only with special keys. The entire electronic part shall be modular type and can be removed from the call station enclosure for easy maintenance.
Wall/ column mounted instruments shall be heavy duty type and shall also be suitable for dust and noise laden atmosphere.

Call stations transmitter/microphone shall be dynamic noise cancelling type and anti-side control facility shall be inbuilt.

Constructional Features of wall/column mounted indoor/outdoor station are as follows:

(i) Material: special plastic/ fibre glass reinforced polyester /high impact polycarbonate/stainless steel or any other suitable material subject to approval of owner.
(ii) Dust tight weatherproof pilfer proof type
(iii) Plug in front unit with all functional parts
(iv) One “Press to Page” push button/ key
(v) One “Press to Mute Loudspeaker” push button/ key
(vi) Dial keypad (10-digit dial pad & at least 2 special keys)
(vii) Pre-amplifier and Power amplifier
(viii) Call or busy signal by light emitting diodes
(ix) Noise compensated inbuilt microphone with anti-side tone control facility& dynamic compression and PTT operation
(x) Microphone sensitivity and volume control
(xi) Potential free relay point
(xii) Booster amplifier
(xiii) Direct intercom connections
(xiv) Can be switched to low volume
(xv) Led indication of incoming call and line busy, prioritized
(xvi) Loud speaker: 15 W
(xvii) Frequency range: 300 hz to 3.4 khz
(xviii) Electrical data booster amplifier - output power: 25 w
(xix) Operating temperature: -10° to +60° celcius
(xx) Protection class: IP-65
(xxi) Area of use: Non hazardous

6.3.4 Type D-Wall/ Column mounted explosion proof station:

Explosion proof field call stations shall be provided in hazardous areas as per requirement. The field call station shall be complete with microphone, speaker and amplifier but without handset. The communication shall be possible through built in microphone.

Constructional Features of wall/column mounted explosion poof station are as follows:

(i) Material: special plastic/ fibre glass reinforced polyester /high impact polycarbonate/stainless steel or any other suitable material subject to approval of owner.
(ii) Explosion proof EEX-d type, water proof
(iii) Plug in front unit with all functional parts
(iv) Dial keypad
(v) Call or busy signal by light emitting diodes
(vi) Noise compensated inbuilt microphone with anti-side tone control facility & dynamic compression and PTT operation
(vii) Microphone sensitivity and volume control
(viii) Potential free relay point
(ix) Booster amplifier
(x) Direct intercom connections
(xi) Can be switched to low volume
(xii) Led indication of incoming call and line busy, prioritized
(xiii) Loud speaker: 15 W
(xiv) Frequency range: 300 hz to 3.4 khz
(xv) Electrical data booster amplifier - output power: 25 w
(xvi) Operating temperature: -10° to +60° celcius
(xvii) Protection class: IP-65
(xviii) Area of use: Hazardous

6.3.5 Type E-Portable station:

Portable type call stations with network compatible ports shall be used at certain location where operational personnel are not present normally. Necessary network connection, power supplies etc. shall be provided at these locations. The locations distributed among different zones shall be decided during detailed engineering.
The network compatible ports shall be suitable for outdoor operation with IP 55 degree of protection.
Degree of protection of portable station shall be IP 55. Portable stations shall be light in weight but sturdy in design. Length of connecting wire from network compatible port to portable station should be 2 meter minimum.

6.4 FLOOR/WALL MOUNTED ACOUSTIC HOOD

The call stations in noisy areas like turbine hall, BFPs, Mill area etc. shall be housed in acoustic hoods. An industrial type free standing, floor mounting hood/ wall mounting hood shall be used for providing the above requirement. The design noise level within the hood shall be limited to a maximum of 60 dB SIL.

(i) Material - Rot/vandal resistant glass re--enforced polyester

/Hot-galvanized sheet steel or stainless steel with 15-watt lamp

(ii) Self-colour-yellow, visible during emergency/Paint- Powder Coated
(iii) Luminous yellow green glow in dark condition, lasting up to minimum 10 hours or more
(iv) Sound absorbent- Up to 12 dB(A) when it will be used as Acoustic Hood
(v) Resistant to chemical spillage/vapours and are fire-retardant and weather proof
(vi) Flashing beacons telephones and sounders can be attached to the hood
(vii) Temperature Range: +60 Deg C to -10 Deg C

6.5 WEATHER PROTECTING CANOPY

Weather protecting canopy shall be provided wherever required for field call stations. The canopy shall be made of mild steel/ glass fiber material to house the field call stations. It shall have cover to open from the side. When the canopy cover shall be opened, it shall be in open position and shall have to be closed manually.

6.6 LOUD SPEAKERS

The loudspeakers shall be cone type/weatherproof horn type /explosion proof horn type, depending upon the location in which they will be installed. The primary winding of the transformer shall be tapped so that the loudspeakers will absorb from the line 100%, 50%, 20%, or 10% of its power, according to the tap used. The reproduced frequency band shall be at least 370 to 6000 Hz for all the transducers, within +/-6 dB range.

6.6.1 WEATHER PROOF HORN TYPE SPEAKER (WEATHERPROOF/ EXPLOSION PROOF)

Re-entrant horn type speakers shall be provided with bracket suitable for wall/ column mounting. The mounting bracket shall be with adjustable base suitable for vertical and horizontal movement. The horn type loudspeakers shall be weatherproof in all locations and explosion proof type depending upon the location in which they will be installed.

(i) Housing: Special Plastic/die cast aluminum/ polyester resin armored with fiber glass/equivalent industrial grade material
(ii) Connection: Screw Terminal
(iii) Ingress Protection: IP65
(iv) Mounting: Plastic Bracket/Stainless Bracket
(v) Rated Power: 15 watts
(vi) Sound Pressure Level 1W,1m: 110 dB
(vii) Frequency Range: 370Hz to 7000Hz
(viii) Operating Temperature: -10°C to 60°C

6.6.2 CONE TYPE SPEAKER

a) Permanent magnet, cone type speaker shall be housed in a sturdy metal cabinet suitable for wall/ column or ceiling mounting as specified in the schedules and drawings.
b) The cabinet shall have grilled metal faceplate to diffuse high frequencies and prevent damage to the speaker. Housing shall be treated with acoustic under-coats to prevent resonance.

6.6.2.1 INDOOR WALL/COLUMN MOUNTED SPEAKER (10WATT)

(i) Housing: Special Plastic
(ii) Ingress Protection: IP40
(iii) Connection: Clamp
(iv) Volume Control: Required
(v) Rated Power: 6 Watt
(vi) Sound Pressure Level 1W,1m: 91dB
(vii) Effective Frequency Range: 100 to 20000Hz

6.6.2.2 CEILING MOUNTED SPEAKER (6WATT)

(i) Housing: Mild steel
(ii) Sound pressure level, power Watts/1m, dB: 103 dB
(iii) Effective frequency range: 100-15,000 Hz
(iv) Operating Temperature: 0°C to +50°C
(v) Protection class: IP-65

6.7 JUNCTION BOXES

Wherever required, junction boxes shall be provided by the vendor.

Material & Fiber glass reinforced polyester (FRP) 4 mm
thick/ Mild Steel (MS) 2mm thickness: thick/ Al LM6 3 mm thick

DOP: IP 55 For all applications except CHP IP 65 for CHP area

6.8 NETWORK SWITCHES

All the network switches shall be of high quality and shall be sized to meet the functional requirements. The location of network switches shall be decided during detailed engineering.

6.9 PC STATION

PC station shall be provided for overall viewing and monitoring of PA system functionality in plant area. It shall be provided with PA system management software. Further, Integrated test equipment to identify faults on the external loudspeaker lines along with a Notebook PC for testing purposes at remote locations as a maintenance terminal together with the existing PC shall be utilized for testing purposes at the main equipment.

6.10 CABLES

6.10.1 CAT 6 CABLE

Cat 6 cable shall be Unshielded Twisted pair (UTP).

(i) Conductor: Solid tinned copper
(ii) Nominal DC Resistance: 67 ohms/1km
(iii) Nominal Impedance: 100 ohms+/-15 Ohms
(iv) Nominal Capacitance: 46pf/m
(v) Nominal Velocity of Propagation: 68%

(vi) Nominal Attention: 100 MHz: - 19.9 dB/100m
155MHz: - 25.3 dB/100m
200 MHz: - 29.2 dB/100m

(vii) Insulation Materials: Poly Vinyl Chloride

6.10.2 SINGLE MODE FIBER OPTIC CABLE

(i) No. of Cores: 4/6/8/12 Core
(ii) The fiber shall be full spectrum, low water peak type
(iii) Guiding standard: ITU-T recommendation G.652.D and IEC 60793-2-50
(iv) Bandwidth: 10Gbps
(v) Core Diameter: 9 µm (approx.)
(vi) Cladding diameter: 125 µm (approx.)
(vii) Nominal Velocity of Propagation: 68%
(viii) Optical laser source wave length: 1310nm/1550 nm
(ix) Attenuation level: 0.34 dB/km or better at 1310 nm, 0.21 dB/km or better at 1550 nm
(x) Inner Sheath and Outer Sheath: Polyethylene
(xi) Armoring: Corrugated steel tape
(xii) Patch cord, Pigtails and connectors: Single mode and duplex type and same throughout the network
(xiii) Bend Radius: 20X outside diameter for installed load and 10X outside diameter for long term load

6.10.3 POWER CABLE

(i) Conductor: stranded compacted annealed copper conductor
(ii) XLPE insulated
(iii) Inner sheath: Extruded PVC type ST2
(iv) Armour: Galvanized steel round wire
(v) Outer sheath: Extruded PVC type ST2 with FRLS properties

6.11 E & C SPARES

Spares which may be required during tests, trial, commissioning and during guarantee run shall be supplied by the bidder.

6.12 TOOLS & TACKLE

Bidder, in his proposal, shall indicate a list of all tools and tackle which may be required for erection, maintenance, overhaul and replacement of equipment / component to be supplied under this specification.

7.0 COMMON REQUIREMENTS OF VARIOUS EQUIPMENT OF SUPPLY

7.1 CLEANING, PROTECTION AND PAINTING

All equipment shall be shipped in properly cleaned condition. All the equipment shall be thoroughly cleaned to remove mill scales, rust etc. and properly painted with anti-rust primer, where applicable.

7.1.1 Some of the equipment and accessories, after arrival at site, are likely to be in storage for long periods before they are taken up for erection. Bidder may provide adequate protection for preventing damage due to corrosion, dust / dirt ingress, ageing etc.

7.1.2 Plugs shall be provided at cable entry holes/adapters to avoid entry of dust and foreign particles. Paper cap will not be acceptable.

7.2 IDENTIFICATION, MARKING, PACKING AND STORING

7.2.1 Each equipment shall be individually packed, tagged and protected.

7.2.2 All components whether mounted inside or on the surface of the main equipment, shall have identifying references as per the arrangement drawings and wiring diagrams. Inscription on equipment (labels) shall be in English.

7.2.3 The material shall be packed as per manufacturer's standard to ensure the protection against mechanical damage, jerks, rain etc. during transit and for a prolonged period of storage. Packing procedure shall be subject to the purchaser's approval. All items supplied shall be packed for long term storage under the climatic conditions prevailing at the site. Small items shall be packed in sealed transparent plastic bags with desiccator packs as necessary. Each item shall be clearly marked with its description, purpose and plant designation code as applicable. When more than one item is packed in a single case a general description of the contents is to be shown on the outside of each case and a detailed list enclosed. All cases and other packages must be suitably marked and numbered for identification purposes

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7.3 EARTHING

7.3.1 Earthing of all sheet metallic parts of enclosures of all equipment covered in this specification which are non-current carrying shall be bonded to an earth stud provided in the equipment. The Contractor shall ensure that proper earthing terminals are provided in all equipment covered in this specification.

7.3.2 If microprocessor control, monitoring and information system or backup control system requires its own unique and isolated grounding requirements, then these requirements should be clearly stated and shall be provided, so as to ensure proper operation of the above-mentioned system

7.3.3 Earthing of cabling system: Armour of cables wherever applicable shall be earthed at both ends of cable. For earthing of power supply cable, an additional core shall be provided or else a continuous ground conductor of 16 SWG GI wire shall be run along each conduit run.

7.3.4 The supply and installation of all earthing wires, earthing plates and other materials for earthing the entire PA System shall be under the scope of the Contractor. The Contractor shall properly earth the system so that there is no interference in the communication system due to electromagnetic noise.

8.0 OTHER

8.1 Bidder shall furnish separately the location wise power supply requirements (in watts) for PA system and its allied accessories.

8.2 Makes of equipment/ components shall be subject to purchaser's approval during detailed engineering. However, bidder shall furnish the list of makes along with the offer.

8.4 Bidder shall submit the sets (hard & soft) of Customer approved Document.

8.5 After completion of work at site, bidder shall prepare "AS BUILT DRAWINGS" and "O&M Manuals".

9.0 INSPECTION AND TESTING AT MANUFACTURER'S WORKS

9.1 Inspection of various equipment shall be carried out as per relevant standards.

9.2 All materials, components and equipments covered under this specification shall be procured, manufactured, inspected and tested as per the purchaser's standards and quality plan of vendor duly approved by purchaser.

9.3 All material used for the construction of the equipment shall be new and shall be in accordance with the requirements of this specification. Materials utilized shall be those, which have established themselves for use in such applications.

9.4 All acceptance and routine tests as per relevant standards shall be carried out by the manufacturer. Charges for all these routine and acceptance tests for all the materials shall be deemed to be included in the bid price.

9.5 The supplier shall perform all tests necessary to ensure that the material and workmanship conform to the relevant standards and that such tests are adequate to demonstrate that the equipment will comply with the requirements of this specification. Copy of the standards/ test methods to which the tests will be conducted are to be furnished during detailed engineering stage.

9.6 Test certificates shall be submitted for purchaser's approval before dispatch of the equipment. The purchaser may witness the test at supplier's works, for which sufficient advance notice shall be given before testing.

9.7 Type test reports should be furnished.

10.0 PERFORMANCE GUARANTEE

Bidder shall guarantee that the system offered shall meet the requirement as indicated in this specification and as confirmed by them in various clauses of technical data sheets. If it is proved that the system doesn't conform to performance guarantee, the bidder shall be ready to replace the faulty equipment/ components at site without any extra cost.

11.0 INSTALLATION AND MAINTENANCE MANUAL

11.1 Instruction manuals for the installation, operation and maintenance of PA System shall be furnished before dispatch of the equipment.

11.2 Draft manual shall first be submitted for Purchaser's approval. The manual shall contain minimum following details:

a) General description of equipment

b) Brief system description for which equipment is meant
c) Technical data
d) Salient constructional details
e) Technical leaflets of important components used in the system
f) All drawings
g) Type and routine test certificates
h) Instructions to be followed on receipt of equipment at site and for storage
i) Material handling instructions
j) Erection procedure and checks
k) Pre-commissioning checks
l) Commissioning procedures
m) Operation instructions
n) Maintenance instructions
o) Trouble shooting
p) Safety instructions

12.0 DOCUMENTATION

12.1 DOCUMENTS TO BE FURNISHED WITH THE BID

a) Brief System Description.

b) Filled and stamped Data Sheet B
c) Catalogues of various equipments
d) List of E & C spares
e) List of tools & tackles

12.2 DOCUMENTS TO BE FURNISHED BY THE VENDOR DURING DETAILED ENGINEERING STAGE

All documentation shall be in English language & MKS system.

a) Full description and design of the equipment and its operation.
b) General arrangement drawings cum Technical Datasheet for various equipment as per drawing list.
c) Detailed write up on the method of testing.
d) Interconnection diagram showing the interconnection between main distribution board, master station(s), JBs, call stations, loud speakers covering the size of cable.
e) Cable schedule
f) Operation and maintenance (O&M) manual.
g) Signed and stamped Standard Quality Plan.
h) Test certificates for the tests actually conducted on the equipment
i) Power consumption details (location wise

<u>Erection and Commissioning</u>

1.0 GENERAL

The scope of this specification covers handling and storage at site; installation, testing and commissioning of IP Based Public Address System for efficient and trouble-free operation after installing the same at site.

2.0 CODES AND STANDARDS

The installation shall comply with all currently applicable statutes, regulations and safety codes in the locality where the equipment will be installed. Nothing in this specification shall be construed to relieve the vendor of his responsibility.

3.0 INSTALLATION

The contractor shall carry out total installation work as per the requirements of the specification and instructions of Engineer.

3.1 PA SYSTEM EQUIPMENT INSTALLATION

3.1.1 Installation of PA System equipment shall include erection, connection, grounding, testing and commissioning of the equipment. Installation activity shall also include provision of all fittings, supports, hangers and other erection materials & consumables which are not specifically mentioned but are required to complete the installation work. Bidder shall arrange all erection tools, tackle and calibration instruments.

3.1.2 Equipment shall be brought to the place of work only at the time of erection. Unpacking, handling, assembling and erection shall be as per the guidelines of installation manual and bidder's Field Quality Plan.

3.1.3 Erection shall commence in an area only after the clearance has been obtained from the Engineer. Vendor shall ensure that all activities, which are liable to damage the equipment in that area, have been completed.

3.1.4 The drilling and welding of building steel work for fixing supports and brackets shall not be done without the prior approval of Engineer.

3.1.5 Wherever drilling and welding of building steel work for fixing supports and brackets is done, the same shall be re-painted and restored to the same paint shade as per site requirement at no extra cost to purchaser.

3.1.6 Laying & Termination of various cables, providing earthling of the system and equipment as required shall be in the scope of the bidder.

3.2 ITEMS OF SUPPLY FOR CABLING INSTALLATION WORK

The supply of below listed items shall be considered to be part of cabling installation work:

Cable glandsCable glands shall be single or double compression type as required for the system. Material of glands shall be brass. Nickel plating shall be provided if indicated. Rubber components used in the gland shall be of neoprene. Name/ trade name of manufacturer, type no. and applicable range of outer diameter of cable shall be engraved/ printed on the cable gland.

3.2.1 Cable lugs

Cable lugs shall be of tinned copper. Name/ trade name and size shall be engraved/ printed on each cable lug.

3.2.2 Self-Locking Clamps

Clamps shall be of nylon material having self-locking feature when the cord is looped. They shall be provided with manual lock release. Clamp cord shall not move in the backward direction once it has been locked, unless the lock release is depressed.

3.2.3 Tags

For identification, cables shall be provided with cable number tags of durable fibre, aluminium or stainless-steel sheets. Cable numbers shall be engraved type in case of aluminium or stainless-steel tags, and printed type in case of fibre sheet. Tags shall be of durable quality with a tie hole at each end and shall be provided with non-corrosive wire of sufficient strength for tagging.

3.2.4 100/50 mm galvanized steel cable trays/Rigid steel conduits/ flexible conduits/HDPE pipe for local cabling and earthing wire / other earthing materials for earthing of PA system item shall be supplied by the bidder as part of cabling installation work. HDPE pipe shall be permanently lubricated type with ISI marked. The internal diameter of the HDPE pipe shall be suitably selected so that 50% free space is maintained during cable drawing. The pipe shall conform to DOT standard GR/CDS-08/02 Nov. 2004 with latest amendments

3.3 INSTALLATION OF CABLES AND CONDUITS

3.3.1 The PA system cables will be laid in ready trays routed by BHEL in different areas of power plant for power & signal cables. Power cable will run in separate trays, similarly the signal cables will run in separate trays. Local cabling from nearby main route cable tray (BHEL scope) to PA system equipment terminal shall be through 100/50 mm cable trays/ MS/ PVC conduits/ HDPE Pipe (bidder's scope).

3.3.2 All cables shall be provided with identification tags indicating the cable numbers in accordance with the cable circuit schedule. Tags shall be fixed at both ends of cables and on both sides of floor/ wall crossings.

3.3.3 All cable entries in the equipment shall be sealed by cable glands.

3.3.4 Power cable terminations shall be carried out in such a manner as to avoid strain on the terminals by providing suitable clamps near the terminals.

3.4 ADDITIONAL POINTS OF CONSIDERATION

3.4.1 The installation work shall be carried out in a neat workman-like manner by skilled, experienced and competent workmen.

3.4.2 Installation shall be properly coordinated at site with other services and wherever necessary suitable adjustment shall be made to avoid interference with any part of the building, structures, equipment, utilities and services. Any such adjustment shall be done with the approval of Engineer.

3.4.3 All materials being supplied or consumed during erection by the vendor in the process of erection work shall be of the best quality and according to the relevant standards. All materials shall be got inspected and approved by the Engineer before the same is used for erection work.

3.4.4 Any work like chipping/ breaking of existing structure like walls, floors, fabrications, etc. shall be done after taking prior approval of Engineer.

3.4.5 Any wrong erection shall be removed & re-erected promptly to comply with the design requirements to the satisfaction of Engineer. Re-erection shall be done at no extra cost to the purchaser.

3.4.6 While testing and commissioning, if the system is observed to be not functioning, it shall be the responsibility of the contractor to check, rectify and demonstrate that the defect has been removed to the satisfaction of purchaser.

3.4.7 Before energization of system, physical inspection shall be carried out and all foreign bodies shall be removed and loose connecting bolts etc. shall be tightened.

4.0 QUANTITY MEASUREMENT AND WASTAGE ALLOWANCE

4.1 For all payment purposes, measurement shall be made on the basis of the execution drawings/ physical measurements. Physical measurements shall be made by the contractor in the presence of the Engineer.

4.2 Wastage allowance shall be kept in consideration while making material appropriation of supplied items.

5.0 COMMISSIONING & SITE ACCEPTANCE TESTING

5.1 Bidder is responsible for delivering a fully functional equipment that meets all the requirements of the Specification and applicable standards. The Commissioning processes will demonstrate the above to Owner, before handing over of the System. System Commissioning shall comprise of a number of different activities as described below culminating in the acceptance of the operational System by Owner. Bidder shall provide all necessary test equipment required to carry out the Commissioning and acceptance testing.

5.2 Following tests are to be performed at site:

a) Insulation resistance, HV test for cables (as applicable).
b) Rated output power.
c) Performance of PAGE and PRIVATE channels for all equipments in the entire Public Address System.
d) Proper functioning of UPS in case of Power failure.
e) Test to ensure that dB level of announcement at any station by its own call station shall be lower than announcement at the same station by any other station.

5.3 Bidder to perform all site tests. During contract stage bidder to furnish FQP indicating details of the tests & the standards to which these conform for purchaser’s approval.

5.4 The Owner may ask for any tests at site which in his opinion are necessary to determine that the works comply with the specification, manufacturer's instruction or the applicable IS code of installation. The Contractor shall be responsible for conducting the tests and shall bear the cost of such additional tests.

5.5 The contractor shall have to bring all testing equipment & instruments to carry out the job. All instruments shall be calibrated to the satisfaction of the Engineer before actual testing and tests shall be conducted by qualified & experienced personnel.

5.6 All documents/ records regarding test data and all other measured values shall be submitted to Engineer for approval and subsequent record and reference. The results of all tests shall conform to the specification requirements as well as any specific performance data guaranteed during finalization of contract.

6.0 PRICES

6.1 GENERAL

Unit prices listed out in this clause shall be applicable for payment to the contractor for activities covered under this specification. The following shall be kept in consideration while quoting the prices:

6.2 UNIT PRICES OF INSTALLATION WORK

Detailed requirement for all the items is given in the specifications and Annexures.

a) Unit price of installation shall include transportation of materials from Vendor's/ Owner's storage yard to work site, handling, testing before erection, testing after erection and commissioning of materials including supply and installation of all associated materials (including support materials) and consumables, carrying out of all associated minor civil works and furnishing of all skilled/ unskilled labour, supervisory and commissioning staff.

b) Price of earth connections are to be included in the erection price of equipment as above.

c) No separate prices shall be applicable for termination of cables. Cable termination shall include drilling of gland plates, fixing of glands, ferrules and lugs and connection to the equipment.

d) Purchaser reserves the right to delete/ add any of the equipment or services from the bidder's scope of work.

e) The unit prices quoted shall be for supply and/ or installation as explained in detail in the clauses in subsequent paragraphs. No other prices shall be applicable for the purpose of payment.

f) While quoting the prices for installation, the following shall be considered as part of job:

    i. Cable glands and lugs
    ii. Clamps, ferrules, aluminium/ stainless steel tags as per the project requirements
    iii. Fasteners like nuts, bolts, washers, spring washers, rawl plugs, anchoring bolts and lugs etc.
    iv. Conduit, HDPE Pipe, Cable Trays, etc. for local cabling
    iv. Conduit plugs, gaskets, couplers, and insulated bushings
    v. Sealing compounds for wall and floor openings

- vi. Consumables like enamels, cold zinc paint, electrodes for welding etc.
- vii. Materials for minor civil works

g) The following shall be arranged by the contractor at no extra cost:
- i. All unskilled and skilled labour
- ii. All supervisory and commissioning staff
- iii. All facilities/ equipment for site fabrication such as cutting, bending and drilling equipment
- iv. Welding set(s)
- v. Material handling equipment
- vi. All special tools and tackles for erection
- i. All testing equipment

h) Requirement of Field Quality Plan shall be considered in the quoted prices.

i) Instruments required for testing & commissioning shall be arranged by the contractor and shall be taken back after E & C.

j) Fabrication and painting of support structures of various equipments shall be in contractor's scope.

DATA SHEET - C

S.No.	DESCRIPTION	UNIT	PARTICULARS
1.0	SYSTEM DESIGN DATA		
1.1	Design ambient temperature:	^{0}C	
2.0	Applicabe Standards		
2.1	Whether all standards Specified in specification are forwarded. :	[ ] Yes [ ] No	

3.0 COMPLETE SYSTEM REQUIREMENTS

a) Frequency response : Hz

b) Hum & noise level or : Signal to noise level

4.0 SCOPE OF SYSTEM DESIGN ENGINEERING : [ ] Included [ ] Excluded

5.0 POWER SUPPLY

5.1 Whether the system suitable : For operation for power supply Details given in specification [ ] Yes [ ] No

5.2 Power supply requirement at : 240V AC kVA

6.0 CONSTRUCTIONAL REQUIREMENTS

6.1 AMPLIFIERS : (To be furnished Separately for each type of amplifier) Pre- Line Loud Speaker Amplifier Amplifier Amplifier

a) Name of the manufacturer :

b) Type and manufacturers : Catalogue no.

c) Power supply details :

d) Full load consumption (VA) :

e) Rated load/ (W/Ohm): Output impedance
f) Max. Ambient conditions :

g) Output voltage (V) :

h) Frequency response (Hz) :

i) Total harmonic (%):

j) Noise level (db) :

k) Power band width (Hz):

l) Construction :

m) Controls provided

i. Cont. variable: [ ] Yes [ ] No Volume control

ii. Standby and idle : [ ] Yes [ ] No Time power supply
Cut-off arrangement Arrangement

iii. Bass & treble: [ ] Yes [ ] No Control

n) Sensitivity w.r.t. (mV): Nominal output

o) Output connections :

p) Indications :

6.2 HANDSETS

6.2.1 Master Handset Station(s)

a) Name of the manufacturer :

b) Type and manufacturer's : Catalogue no.

c) Material :

d) Degree of protection:

e) Surface treatmentWhether all Yes / No

f) Whether all features: Provided on master handset station as per Specifiction requirement.

g) Type of Circuit: Protection

h) Mounting arrangement

i) Dimension (L*D*H)

j) Weight

6.2.2 HANDSETS (To be furnished Separately for each type) — Outdoor/Indoor, Indoor desk mtd., Wall mtd.

a) Name of the manufacturer:

b) Type and manufacturer's: Catalogue no.

c) Material:

d) Impedance of the transmitter: Transmitter — Ohm

e) Frequency response of The : Receiver transmitter — Hz

f) Impedence of the Receiver : Ohm

g) Receiver oiutput : mV
Hz Response

h) Reciver frequency response — Hz

i) Details of provision for Noice Cancellation features:

J) Details of provision for Directional features:

k) Whether all features: No Provided on handset: station as per specification requirements. — [ ] Yes [ ] No

l) Degree of protection:

m) Surface treatment :

n) Mounting :

o) Dimension with control : box (L*D*H) — mm

p) Weight: — kg

6.3 LOUDSPEAKERS (To be furnished separately for each type) — Reentrant, Cone

a) Name of the manufacturer :

b) Type and manufacturer's catalogue no.

c) Material :

d) Degree of protection:

e) Surface treatment

i. Exterior surface :

ii. Interior surface :

f)	Impedance matching volts : (Transformer details)		Ohm
g)	Output power		
	i. rms :		Watt
	ii. Peak :		Watt
h)	Frequency response:		Hz
i)	Cut-off frequency :		Hz
j)	Sound level at 1000 Hz Distance	: db/watt mtr.	
k)	Controls provided :		
l)	Bell diameter:		mm
m)	Acoustic length :		mm
n)	Dispersion angle :		Deg.
o)	Speaker diameter :		mm
p)	Weight:		kg

6.4 MAIN DISTRIBUTION BOX

a)	Name of the manufacturer :	
b)	Type :	
c)	Construction :	
d)	Material :	
e)	Sheet steel thickness:	mm
f)	Number of ways :	
g)	Degree of protection:	
h)	Surface treatment :	
i)	Dimensions (L*D*H):	mm

6.5 JUNCTION BOX (to be furnished
JB-1
JB-2
JB-3

separately for each type)

a) Name of the manufacturer :

b) Type :

c) Construction :

d) Material :

e) Sheet steel thickness: mm

f) Number of ways :

g) Degree of protection:

h) Surface treatment :

i) Dimensions (L*D*H): mm

6.6 COMMON REQUIREMENTS OF VARIOUS EQUIPMENTS

6.6.1 Surface Treatment

a) If painted;

i Application :

ii. Colour of paint

1. Inside :

2. Outside :

iii. Minimum thickness: microns

b). If galvanized;

i). Method :

ii) Applicable Standard:

iii) Minimum thickness: micronsof zinc deposit on all points

iv) Weight of zinc: g/m^2

6.6.2 Labels

a) Material: [ ] Anodised Aluminium

[ ] Stainless Steel

6.6.3 Earthing

a) Name of the manufacturer :

b). Type

c) Size : mm

d) Details of earthing : Arrangement

7.0 OTHER MAJOR EQUIPMENTS OF SUPPLY

7.1 CABLES (To be furnished Separately for each type of Cable)

7.1.1 Applicable Standard

IS: 1554 Part 1 & IS: 694 (In general) : [ ] Yes [ ] No

7.1.2 Name of the manufacturer for

a) Power cable :

b) Signal cable :

c) Loud Speaker cable :

7.1.3 Whether FRLS type cableProvided for

a). Power cable : [ ] Yes [ ] No

b) Signal & loud speaker: [ ] Yes [ ] NoCable

7.1.4 Voltage Grade for

a) Power cable : Volts

b) Signal & loud speaker: VoltsCable

7.1.5 Conductor

a) Material

i) Power cable :

ii) Signal & loud: Speaker cable

b) No. of pairs/cores, Conductor cross sectionalArea, no. of strands and Dia. of each strand for

i. Power cable :

ii. Signal cable :

iii. Loud Speaker cable :

7.1.6 Insulation

a) Material :

b) Application :

c) Volume resistivity :

7.1.7 Identification of cores/pairs

a). Power cables: Control cables
up to5 cores & Paired cables
paired cables

b). Control cables above:5 core

7.1.8 Paired cables

a). Min. number of twists
per metre for paired cables

7.1.9 Inner sheath

a). Material [ ] Type ST1
[ ] Type ST

b). Whether FRLS [ ] Yes [ ] No

c). Fillers Provided

d). Material for filler

e). Method of application

i. with fillers : [ ] Pressure Extruded
[ ] Vacuum Extruded

ii. without fillers:

7.1.10 Armour :

7.1.11 Outer sheath

a) Material : [ ] Type ST1[ ] Type ST2

b) Application :

c) Colour:

7.1.12 Characteristics of FRLS sheath

a) Oxygen index (min.):

b) Temp. index (min.) :

c). Acid gas generation :(max.)

d). Smoke density rating:(max.)

7.1.13 Progressive sequential length : [ ] Yes [ ] Nomarking provided on outer

7.2 CONDUITS

a) Name of the manufacturer :

b) Type :

c) Gauge :

d) Size : mm

7.3 ITEMS OF SUPPLY FOR CABLING INSTALLATION WORK

7.3.1 Cable Glands

a) Type : [ ] Single compression [ ] Double compression

b) Whether Nickel plating : [ ] Yes [ ] Nodone

8.0 LIST OF SPARES (Bidder to furnish thelists)

a) Start Up Spares list : [ ] Yes [ ] Noenclosed

b) O&M Spares list enclosed : [ ]

Yes [ ] No

9.0 DOCUMENTATION

Whether following documents enclosed:

a) Full description and design of the equipment : [ ] Yes [ ] No
and its operation.

b). Dimensional and mounting details of all equipment : [ ] Yes [ ] No

c) General arrangement drawings for handset: [ ] Yes [ ] No
station (all types), loud speakers (all types),
JBs, Auto changeover Box, distribution box etc.

d). Auto changeover switching scheme: [ ] Yes [ ] No

e). Bill of quantities of cables, JB boxes: [ ] Yes [ ] No

f). Detailed write up on the method of testing: [ ] Yes [ ] No

g) Copies of all test: [ ] Yes [ ] Nocertificates
for the tests actually conducted on the equipment.

h) Final Quality Plan (enclosed in Vol III) [ ] Yes [ ] No

i) Field quality plan [ ] Yes [ ] No

10.0 PERFORMANCE GUARANTEE

Bidder shall guarantee that the system offered shall meet the requirement as indicated in this specification and as confirmed by them in various clauses of technical data sheets. If it is proved that the system doesn't conform to performance guarantee, the bidder shall be ready to replace the faulty equipment/ components at site without any extra cost.

11.0 INSTALLATION AND MAINTENANCE MANUAL

11.1 Instruction manuals for the installation, operation and maintenance of PA System shall be furnished before dispatch of the equipment.

11.2 Draft manual shall first be submitted for Purchaser's approval. The manual shall contain minimum following details:

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b) Brief system description for which equipment is meant
c) Technical data
d) Salient constructional details
e) Technical leaflets of important components used in the system
f) All drawings
g) Type and routine test certificates

h) Instructions to be followed on receipt of equipment at site and for storage
i) Material handling instructions
j) Erection procedure and checks
k) Pre-commissioning checks
l) Commissioning procedures
m) Operation instructions
n) Maintenance instructions
o) Trouble shooting
p) Safety instructions

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e) List of tools & tackles

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All documentation shall be in English language & MKS system.

a) Full description and design of the equipment and its operation.
b) General arrangement drawings cum Technical Datasheet for various equipment as per drawing list.
c) Detailed write up on the method of testing.
d) Interconnection diagram showing the interconnection between main distribution board, master station(s), JBs, call stations, loud speakers covering the size of cable.

Chapter 34: Earthing and DSLP

Electrical measurements of the subsoil at various depths up to 20 meters shall be made at the site of each substation in order to determine the layered effects of the ground from which the effective ground resistivity and hence the expected resistance of the proposed earth grid system may be predicted. Wenner's 4 - Electrode method as per IEEE-Std. 81 may be followed for measurement of earth resistivity. The earthing system shall comprise a mesh grid formed by 40mm dia M.S. Rod conductor buried directly in the ground 700mm below FGL. The mesh system shall be designed suchthat the grid potential rise limits the step and touch voltage to a value not greater than the maximum tolerable touch potential. The mesh system shall be designed as per IEEE 80 and IS 3043 with fault clearance time of 1 second. The design of earth mat shall be submitted to AEGCL approval. The calculations shall be carried out considering with and without a layer of crushed stone of thicknes.

150mm. The resistance of the earth mat shall not exceed 1 Ω. The resistivity of the stone for gravelling shall be 3000 ohm-m under wet condition for which resistivity measurement shall be done. For measurement purpose, one sample of stones from each source (in case stones are supplied frommore than one source) shall be used.

While designing the ampacity of the buried conductor suitable corrosion allowance shall be considered for Forty (40) years. The grid conductors and risers below ground shall be welded suitably for maintaining a high degree of mechanical rigidity and electrical connectivity.

The earthing system shall be designed so as to include all overhead line terminal towers, which shall be earthed by extending the system so as to envelope all towers within the earth system. Each tower shall be bonded directly to the earth system from at least two locations. Structures and masts for lighting and security surveillance equipment shall also be within the perimeter of the earth grid.

Where a metal substation fence is provided, this shall be bonded electrically to the earthling grid on each side at points adjacent to each corner. The location of the mesh conductors shall be such as to enable all items of equipment to be connected to the earth system via the shortest possible route.

The current density of the earth conductor shall be not greater than 45A/mm2. Single connections between equipment and the earth system shall carry the total short circuit current, but the cross- sectional area of branch connections may be reduced to take account of current distribution in two or more conductors. A distribution factor of 60 per cent shall be assumed for this purpose, i.e. the cross- sectional area of branch connections may be reduced to 60 per cent of the corresponding single conductor.

The grid voltage rise under fault conditions shall not exceed 10 kV.
Earthing and lightning protection system installation shall be in strict accordance with the latest editions of Indian Electricity Rules, relevant Indian Standards and Codes of practice and Regulations existing in the locality where the system is installed as below:

Code of practice for Earthing IS: 3043
Code of practice for the protection of Building and allied structuresagainst lightning IS: 2309.
CEA Safety Regulations 2010 & Indian Electricity Act 2003 with latestamendments.
d) National Electricity Safety code IEEE-80

Details of Earthing System

EARTHING CONDUCTORS

General

All conductors buried in earth and concrete shall be of mild steel. All conductors above ground leveland earthing leads shall be of galvanised steel. The minimum sizes of earthing conductor to be used are as indicated below table no A.

1. 1 Constructional Features

1.2.1 Galvanised Steel

a) Steel conductors above ground level shall be galvanised according toIS:2629.
b) The minimum weight of the zinc coating shall be **610** gm/sq.m **for normalarea and 900 gm/sq.m for coastal area as specified in Section-Project** and minimum thickness shall be 86 microns.
c) The galvanised surfaces shall consist of a continuous and uniformly thick coating of zinc, firmly adhering to the surfaces of steel. The finished surface shall be clean and smooth and shall be free fromdefects like discoloured patches, bare spots, unevenness of coating, spelter which is loosely attached to the steel globules, spiky deposits, blistered surfaces, flaking or peeling off etc. The presence of any of these defects noticed on visual or microscopic inspection shall render the material liable to rejection.

1.3 **Tests**
In accordance with stipulations of the specifications galvanised steel shall be subjected to four oneminute dips in copper sulphate solution as per IS : 2633.

TABLE A

Sl No.	Item	Size	Material
a)	Main Earthing Conductor to be buried in ground	40mm dia M.S. Rod	Mild Steel
b)	Conductor above ground& earthing leads(for equipment)	75x12mm G.S. flat	Galvanise dSteel
c)	Conductor above ground& earthing leads(for columns & aux. structures)	65x12mm G.S. flat	Galvanise dSteel
d)	Earthling of indoor LT panels, Controlpanels and outdoor marshalling boxes, Junction boxes & Lighting Panels etc.	50x6 mm G.S. flat	Galvanise dSteel
e)	Rod Earth Electrode	40mm dia, 3000mm long	Mild Steel as per IS:2062/ SAE1018
f)	Perforated Pipe Earth Electrode (in treatedearth pit) as per IS.	50mm dia, 3000mm long	Mild Steel as per IS:2062/SAE1018

g)	Earthing for motors	25x4mm GS flat	Galvanised Steel
h)	Earthing conductor along outdoorcable trenches	50x6mm GS flat	Galvanised Steel

I)	Earthing of Lighting Poles (for lightingpoles outside switchyard)	50x6mm GS flat	Galvanised Steel
j)	Isolator MOM Box	75X12 mm GS flat & Flexible copper braid	Galvanised steel andcopper braid
k)	Insulator Guy Arrangement	75X12 mm GS flat	Galvanised Steel
l)	Earthing of Lightning mast and Columnwith peak	75X12 mm GS flat with Pipe Electrode in treated pit	Galvanised Steel

Equipment and Structure Earthing:

i) Earthing pads shall be provided for the apparatus/equipment at accessible position. The connection between earthing pads and the earthing grid shall be made by two short earthing leads (one direct and another through the support structure) free from kinks and splices.

ii) Whether specifically shown in drawings or not, steel/RCC columns, metallic stairs etc. shall be connected to the nearby earthing grid conductor by two earthing leads. Electrical continuity shall be ensured by bonding different sections of hand-rails and metallic stairs.

iii) Metallic pipes, conduits and cable tray sections for cable installation shall be bonded to ensure electrical continuity and connected to earthing conductors at regular interval.

iv) Metallic conduits shall not be used as earth continuity conductor. Metallic conduits shall be earthed with GI wire of suitable size.

v) Wherever earthing conductor crosses or runs along metallic structures such as gas, water, steam conduit, etc. and steel reinforcement in concrete it shall be earthed.

vi) Railway tracks within switchyard area shall be earthed at a spacing of 30m and also at both ends.

vii) Earthing conductor shall be buried 2000 mm outside the switchyard fence. All the gates and every post of the fence shall be connected to earthing grid. The stone spreading shall also be done 2000 mm outside switchyard fence. The criteria for stone spreading shall be followed in line with requirement specified elsewhere in the specification.

viii) Flexible earthing connectors shall be provided for the moving parts.

ix) A continuous ground conductor of 16 SWG GI wire shall be run all along each conduit run. The conductor shall be connected to each panel ground bus. All junction boxes, receptacles, switches, lighting fixtures etc. shall be connected to this 16 SWG ground conductor.

x) 50mm x 6mm GS flat shall run on the top tier and all along the cable trenches and the same shall be welded to metallic inserts holding the cable trays/ racks. All racks shall welded to the inserts. Further this flat shall be earthed at both ends and at an interval of 30 mtrs.

xi) For 400kV, 220kV and 132kV, Each Surge Arrester shall be directly connected to two numbers perforated pipe electrodes with test link in treated earth pit (as per IS); each Voltage Transformer shall be directly connected to one number perforated pipe electrodes with test link in treated earth pit (as per IS); which in turn shall be connected to main earth mat. For 33kV, Each Surge Arrester, Voltage Transformer shall be directly connected to one number perforated pipe electrodes with test link in treated earth pit (as per IS) which in turn shall be connected to main earth mat.

xii) Lightning Mast and Towers with Peak shall be directly connected to two numbers perforated pipe electrodes with test link in treated earth pit (as per IS) which in turn shall be connected to main earth mat. Connection from earthing terminal to pipe electrode shall be done by 75x12mm GS Flat.

xiii) Each earthing lead from the neutral of the Transformer/Reactor shall be directly connected to two numbers perforated pipe electrodes with test link in treated earth pit (as per IS) which in turn shall be connected to main earth mat. The pit shall be filled with Bentonite powder mixed with lomy soil at a ratio 1:10. The electrodes shall be buried in Cement Concrete pit with a ISI marked cast iron cover. Connection from earthing terminal to pipe electrode shall be done by 75x12mm GS Flat. The transformer body and all accessories associated with transformer/reactor like cooling banks, radiators etc. shall be connected to the earthing grid at minimum two points by 75x12mm GS Flat.

xiv) Auxiliary earthing mat comprising of 40mm dia M.S. rods closely spaced (300mm x 300 mm) conductors shall be provided at depth of 300mm from ground level below the operating handles of the M.O.M. Box of the isolators and Earth Switch. M.O.M. boxes shall be directly connected to the auxiliary earthing mat. Flexible copper braid connection to be provided between MOM box and GS flat to take care of soil sagging. The size of auxiliary earthing mat shall be of 1500mmx1500mm for 400kV, 220kV and 132kV and 900mmX900mm for 33kV. Factory welded auxiliary earthmat is preferable.

xv) For Power Cable Metallic sheaths and armour of all multi core power cables shall be earthed at both equipment and switchgear end and with Link box as and when required. Sheath and armour of single core power cables shall be earthed at switchgear end only.

xvi) Metal parts of all equipment, other than those forming part of an electrical circuit, shall be connected directly to the main earth system at two points.

xvii) Gate posts forming part of the substation fence shall be bonded together with below ground connections and the gates themselves shall be electrically bonded to the posts at two points through flexible braids.

After installation of the earth system the Contractor shall measure the resistance of the substation. The method used shall preferably be the "fall of potential" method, requiring the availability of a local low voltage supply, but other methods using an earth resistance meter will be acceptable in the event of a local supply being unavailable.
The fencing of the switch yard also to be earthed by using GS flats of size 75x12mm at each post. The corner points of the switch yard shall be provided 40 mm dia MS rod of length 3000mm.

EARTHING

The spacing for the main earthmat shall be as per earthmat calculation prepared by contractor andapproved by AEGCL during detailed engineering.
The main earthmat shall be laid in the switchyard area in accordance with the approved earthmat layout and earthing design calculation.

9.5.2 Wherever earthing conductor crosses cable trenches, underground service ducts, pipes, tunnels, railway tracks etc., it shall be laid minimum 500mm below them and shall be circumvented in case it fouls with equipment/structure foundations.

9.5.3 Tap-connections from the earthing grid to the equipment/structure to be earthed shall be terminated on the earthing terminals of the equipment/structure as mentioned in this chapter.

9.5.4 Earthing conductors or leads along their run-on cable trench, ladder, walls etc.shall be supported by suitable cleating at intervals of 750 mm. Whereverit passes through walls, floors etc., PVC sleeves shall be provided for the passage of the conductor and both ends of the sleeve shall be sealed to preventthe passage of water through the sleeves.

9.5.5 Earthing conductor around the building shall be buried in earth at a minimumdistance of 1500 mm from the outer boundary of the building.

9.5.6 Earthing conductors crossing the road shall be laid 500mm below road or atgreater depth to suit the site conditions.

9.5.7 Earthing conductors embedded in the concrete shall have approximately 50mm concrete cover.

9.5.8 All exposed joints shall be at a minimum height of 150 mm above floor or ground level.

9.8 JOINTING

9.8.1 Earthing connections with equipment earthing pads shall be bolted type. Contact surfaces shall be free from scale, paint, enamel, grease, rust or dirt. Two bolts shall be provided for making each connection.

9.8.2 Connection between equipment earthing lead and main earthing conductors and between main earthing conductors shall be welded type. For rust protections, the welds should be treated with red oxide primer and afterwards coated with two layers bitumen compound to prevent corrosion.

9.8.3 Steel to copper connections shall be brazed type and shall be treated to prevent moisture ingression.

9.8.5 All weldings shall be electric arc welding. All welded joints shall be allowed to cool down gradually to atmospheric temperature before puttingany load on it. Artificial cooling shall not be allowed.

9.8.6 All arc welding with large dia. conductors shall be done with low hydrogencontent electrodes.

9.8.7 The 75x12mm GS flat shall be clamped with the equipment support structures at 1000mm interval.

9.11 INSULATING MATS

9.11.1 The scope covers supply and laying of insulating mats—All conforming toIS: 15652-2006.

9.11.2 These insulating mats shall be laid in front of all floor mounted AC and DC switchboards and switchgear panels located in control room building/ Switchyard panel room.

9.11.3 The insulating mats shall be made of elastomer material free from any insertions leading to deterioration of insulating properties. It shall be resistant to acid, oil and low temperature.

9.11.4 Upper surface of the insulating mats shall have small aberration (rough surfacewithout edges) to avoid slippery effects while the lower surface shall be plain or could be finished slip resistant without affecting adversely the dielectric property of the mat.

9.11.5 Insulating mat (wherever applicable) shall be of pastable type, to be fixed permanently on the front of the panels except for the chequered plate area whichshall not be pasted as per requirement.

9.11.6 Width of insulating mats shall generally be of 1.5 meters or as per site requirements. Length shall be supplied as per site requirements.

DIRECT STROKE LIGHTNING PROTECTION

12.1 Direct stroke lightning protection (DSLP) shall be provided in the EHV switchyard by lightning masts and shield wires. The arrangement shall be decided after approval of the DSLP calculations.

12.2 The lightning protection system shall not be in direct contact with undergroundmetallic service ducts and cables.

12.3 Conductors of the lightning protection system shall not be connected with theconductors of the safety earthing system above ground level.

12.4 Down conductors shall be cleated on the structures at 2000 mm interval.

12.5 Connection between each down conductor and rod electrodes shall be made viatest joint (pad type compression clamp) located approximately 1500 mm above ground level. The rod electrode shall be further joined with the main earthmat.

12.6 Lightning conductors shall not pass through or run inside G.I. conduits.

12.7 Lightning protection shall also be provided for various buildings like control building, FFPH,Township buildings as per relevant standard.

12.8 Transformer, Bus duct, SF6 to air bushing DSLP shall be provided by LM only.

Chapter 35

TECHNICAL REQUIREMENT OFSELECTIVE LEVEL METER CUM LEVEL GENERATOR

The equipment shall be handheld battery operated, multifunction measuring instrument, intended for the test of Carrier Frequency Systems, Power Line Carrier Communication. The equipment should have Integrated Level Generator. Technical Specifications of the equipment are as under:

S.N.	Particulars	Specifications
A	**Transmitter**	
1.	Frequency range of co-axial Output	5Hzto5MHz
2.	Frequency Accuracy	≤±2ppm
3.	Balanced Outputs	500 Hz to 5 MHz, Impedances:75Ω,120Ω,150Ω,600Ω
4.	Level range of Balanced Output	+10 to-40dBm, for all Impedances
5.	Level range of Coaxial Output,5 Hz to 5MHz	+15dBm to-40dBm, Impedances:75Ω,120Ω,150Ω,600Ω
6.	Level setting resolution	0.001dBm
B	**Selective Receiver**	
1.	Selection modes for Centre Frequency	Facility to set Centre Frequency as Generator Frequency, AFC(Automatic Frequency Capture), Single Fixed, Dual Fixed, Input Frequency
2.	Frequency Range	5Hz to 5MHz
3.	Frequency Accuracy	≤± 2ppm
4.	Frequency Setting resolution	6 digit
5.	Band width	
i)	5Hz to 5MHz:3Hz, 25Hz, 100Hz, 360Hz, 400Hz, 1.95kHz, 3.1kHz &w ideband	
6.	High Level Input	Max Input±300Vpk, Input Impedance 1MΩ
7.	Low level Inputs	Max Input±10Vpeak Input Impedance 75Ω,120Ω,150Ω,600Ω,1MΩ
8.	Balanced Input	Max Input±10Vpeak Input Impedance 75Ω,120Ω,150Ω,600Ω,1MΩ
9.	75ohm Input	Max Input 28Vrms(40dBm/10W)
10.	Measuring range	
i.	With 25Hz bandwidth	-40to+15dBm
ii.	Level display Resolution	4digit,0.001dBm
iii.	Level Accuracy at 0dBm, Freq.>200Hz	±0.3dBm
C.	**Frequency Response Analyzer**	
1.	Frequency Range	5Hz to 5MHz
2.	Gain Accuracy	0.05dB<10kHz 0.1Db + 0.001dB/kHzfor≥10kHz
3.	Phase Accuracy	0.02°<10kHz 0.02°+0.003°/kHzfor≥10kHz
D.	**Impedance Analyzer**	
1.	Impedance Range	100mΩ to 100Kω
2.	Measurements	LCR Measurements (Inductance, Capacitance, Resistance, tandelta, Quality Factor). Impedance versus Frequency Curve
E.	**VSWR Meter**	

1.	Measurements	Forward Power, Reflected Power, %Reflected Power& Frequency under test should be displayed simultaneously
2.	Accuracy	1%≤1MHz 5%>1MHz For Power measurements (Forward & Reflected)
F.	**Oscilloscope**	
1.	Time Base	5us/divto5s/div
2.	Sample Rate	5MS/s
3.	Trigger	Auto, normal or single short
G.	**EMC & Safety Standards**	Compliance to following Standards: EMC Standards:EN61326-1:2013 Safety Standard:EN61010-1
H.	**Programming Interfaces**	USB, RS232, LAN
I.	**Data Storage**	Internal 1GB flash, external USB pendrive, Facility to store 500 Setups, readings and Sweep results
J.	**General Specification**	
1.	Power Supply	9-18VAC adapter or 12V from external battery
2.	Battery Pack	Internal rechargeable battery pack
3.	Display	5.7 inch VGA color
4.	Ambient temperature ranges	0 to 50 degC
5.	Accessories	Cable Set necessary for the Balanced & Unbalanced Leveltransmission & measurements including following: BNC-BNC Cables BNC to Aligator Clips BNC to Pin Tip and Mains adapter Carryingcase Operating Manual Calibration Certificate.

CHAPTER 36: SCOPE AND GENERAL TECHNICAL CONDITION FOR TRANSMISSION LINES

A. Nature of work

The work covered by this Specification is for 400 kV and/or 220 kV and/or 132 kV transmission lines as specified herein and in the attached Schedules. The overhead transmission lines will form part of the AEGCL Transmission System.

B. General particulars of the system

The following are the general particulars governing the design and working of the complete system of which the Works will form a part —

1. Electrical energy is generated at interconnected power stations as three-phase current at a frequency of 50 Hz, and transmitted therefrom by means of overhead lines.
2. The system will be in continuous operation during the varying atmospheric and climatic conditions occurring at all seasons as mentioned in chapter 2 of this bidding document.

36.1.0 SCOPE-

Construction of 400 KV, 220 KV and 132 KV

As indicated in the Bidding Proposal Sheet & scope of work.

Important: For obtaining Right of way (ROW) the contractor shall refer to chapter 2 of this bidding document.

36.2.0 SURVEY (detail & check, estimating of quantities & spotting of towers)

36.2.0.1 General: Preliminary route alignment in respect of the proposed transmission lines has been fixed by the employer subject to alteration of places due to way leave or other unavoidable constraints. The Right of way shall be solved by the contractor and all expenses there of shall be paid by the contractor, which will be reimbursed by AEGCL time to time. However, AEGCL shall render all helps in co- ordination with law and order department for solving the same. Forest clearance if any shall be arranged by AEGCL.

37.2.0.2 Provisional quantities/numbers of different types of towers have been estimated and indicated in the BOQ Schedule given. However final quantities for work shall be as determined by the successful bidder, on completion of the detail survey, preparation of route profile drawing and designing of the different types of towers as elaborated sin the specification and scope of work.

37.2.0.3 The contractor shall undertake detailed survey on the basis of the tentative alignment fixed by the employer. The said preliminary alignment may, however, change in the interest of economy to avoid forest and hazards in work. While surveying the alternative route the following points shall be taken care by the contractor.

a. The line is as near as possible to the available roads in the area.
b. The route is straight and short as far as possible.

c. Good farming areas, religious places, forest, civil and defence installations, aerodromes, public and private premises, ponds, tanks, lakes, gardens, and plantations are avoided as far as practicable.

d The line is far away from telecommunication lines as reasonably possible. Parallelism with these lines shall be avoided as far as practicable.

e. Crossing with permanent objects are minimum but where unavoidable preferably at right angles.

f) Difficult and unsafe approaches are avoided.

g) The survey shall be conducted along the approved alignment only in accordance with IS: 5613 (Part-II/Section-2), 1985.

h) For river crossing/ Crossing of Nallas: Taking levels at 20 metre intervals on bank of river and at 40 metre intervals at bed of river so far as to show the true profile of the ground and river bed. The levels may be taken with respect to the nearest existing towers, pile foundation of towers, base or railway/road bridge, road culvert etc. The levels shall be taken at least 100 m. on either side of the crossing alignment. Both longitudinal and cross sectional shall be drawn preferably to a scale of 1:2000 at horizontal and 1:200 vertical.

i) After completing the detailed survey, the contractor shall submit the final profile and tower schedule for final approval of the employer. The final profile and tower schedule shall incorporate position of all type of towers. To facilitate checking of the alignment, suitable reference marks shall be provided. For this purpose, concrete pillars of suitable sizes shall be planted at all angle locations and suitable wooden/iron pegs shall be driven firmly at the intermediate points. The contractor shall quote his rate covering these involved jobs.

j) Only approved sag template shall be used for tower spotting and the final profiles. However preliminary survey has been done by AEGCL and any further survey required shall be done by the contractor.

37.2.0.4 PROFILE PLOTTING AND TOWER SPOTTING

36.2.0.4.1 The profile shall be plotted and prepared to the scale 1 in 2,000 for horizontal and 1 in 200 for vertical on squared (mm) paper. If somewhere the difference in levels be too high, the chart may be broken up according to the requirements. A 10 mm overlap shall be shown on each following sheet. The chart shall progress from left to right for convenience in handling. The sheet size may be conveniently chosen.

36.2.0.4.2 With the help of sag template, final tower location shall be marked on the profiles and while locating the tower on survey chart, the following shall be kept in mind:
The contractor shall also submit the land schedule on revenue (if required) maps indicating alignment therein duly authenticated by Revenue Inspector & Tahasildar, enumeration of trees with the help of Forest officer and other prominent features required for alignment of the proposed 132 KV line. Final route to be plotted on 1:50000 topo sheet for approval. Detail GIS (Geographical Information System) of towers to be included.

36.2.0.4.3 The number of consecutive spans between the section points shall not exceed 10 in case of straight run on a more or less plain stretch.

36.2.0.4.4 Individual span shall be as near as to the normal design ruling span.

36.2.0.4.5 In different crossing the contractor shall take into consideration the prevailing regulations of the respective authorities before finalizing type and location of the towers. While carrying out survey work, the contractor has to collect all relevant data, prepare and submit drawings in requisite number for obtaining clearance from the PTCC, road, aviation, railways, river and forest authorities.

36.2.0.4.6 The contractor shall remain fully responsible for the exact alignment of the line. If after erection, any tower is found to be out of alignment, the same shall have to be dismantled and re- erected after correction by the contractor at his own cost, risk and responsibility, including installation of fresh foundation, if belt necessary by the employer.

36.2.0.4.7 After peg marking of the angle tower or tension towers, the contractor shall obtain approval from the employer and thereafter pegging of suspension type tower shall be done by the contractor and pegging of all the four legs of each type of towers at all the locations shall be done.

37.2.0.5 SCHEDULE OF MATERIALS

When the survey is approved, the contractor shall submit to the employer a complete detail schedule of all materials to be used in the line. Size and length of conductor etc. are also to be given in the list. This schedule is very essential for finalizing the quantities of all line material. The contractor shall furnish the same.

36.2.1 DETAILED SURVEY/CHECK SURVEY:

The contractor will have to carry out detailed survey of the line for which route map indicating the proposed alignment of the transmission line will be handed over by the Employer. If the detailed survey is already conducted by the Employer for some portion of the line, the profiles for such portion will be handed over to the Contractor for carrying out check survey. It may please be noted that no check survey is required to be conducted for the portion of line for which detail survey is conducted by the contractor himself.

A. Detailed Survey:-

(a) At the starting point of the commencement of route survey, an angle iron spike 65 x 65 x 1000mm shall be driven firmly into the ground to show only 150mm above the ground level. A punch mark on the top section of the angle iron shall be made to indicate location of the surveying instrument. Teak wood pegs 50 x 50 x 650 mm shall be driven at prominent positions at intervals of not more than 750 meter along the transmission line to be surveyed up to the next angle point. 125 mm wire nails should be fixed on the top of these pegs to show the location of instrument. The pegs shall be driven firmly into the ground to show only 100 mm above ground level. At angle positions, stones shall be put up for easy identification. Paint mark in white lead paint shall be put in, about 300 mm squares with a direction indication, on nearby boulders, rocks, or trees, along the complete line alignment. At peg position, identification marks giving the peg position, with reference to painting marks, shall be given. The white lead paint mark shall indicate to the individual the direction of alignment from either direction.

(b) Routing/Re-routing of transmission line through protected/reserved forest area

should be avoided. In case it is not possible to avoid the forests or areas having large trees completely, then keeping in view of the overall economy, the route should be aligned in such a way that cutting of trees is minimum.

(c) The route should have minimum crossings of Major river, Railway lines, National/State highways, overhead EHV power line and communication lines.

(d) The number of angle points shall be kept to minimum.

(e) The distances between the terminal points specified shall be kept shortest possible, consistent with the terrain that is encountered.

(f) Marshy and low lying areas, river beds and earth slip zones shall be avoided to minimize risk to the foundations.

(g) It would be preferable to utilize level ground for the alignment.

(h) Crossing of power lines shall be minimum. Alignment will be kept at a minimum distance of 300 m from power lines to avoid induction problems on the lower voltage lines.

(i) Crossing of communication line shall be minimized and it shall be preferably at right angle. Proximity and parallelism with telecom lines shall be eliminated to avoid danger of induction to them

(j) Areas subjected to flooding such as nalah shall be avoided.

(k) Restricted areas such as civil and military airfield shall be avoided. Care shall also be taken to avoid aircraft landing approaches.

(l) All alignment should be easily accessible both in dry and rainy seasons to enable maintenance throughout the year.

(m) Certain areas such as quarry sites, tea, tobacco and saffron fields and rich plantations, gardens and nurseries which will present the Employer problems in acquisition of right of way and way leave clearance during construction and maintenance should be avoided.

(n) Angle points should be selected such that shifting of the point within 100 m radius is possible at the time of construction of the line.

(o) The line routing should avoid large habitations, densely populated areas, Forests, Animal/Bird sanctuary, reserve coal belt areas, oil pipe, line/underground inflammable pipe lines etc to the extent possible.

(p) The areas requiring special foundations and those prone to flooding should be avoided.

(q) From the field book entries, the route plan and level profile shall be plotted and prepared to the scales of 1:2000 horizontal and 1:200 vertical on 1 mm/5 mm/1 cm square paper.

(r) If the difference in levels be too high, the chart may be broken up according to requirement. A 400 meter overlap shall be shown on each following sheet. The chart shall progress from left to right. For convenience in handling, the sheet size may be limited to 594x841 mm (Al) size.

(s) After completing the detail survey, profiles shall be submitted to the Employer duly spotted with tower for approval. While submitting the profiles after conducting the detail survey, the contractor will also submit a copy of route alignment on the route map indicating the surveyed route.

B. Check Survey:

(a) The Contractor shall conduct the check survey after the profiles are handed over to the Contractor. The check survey shall include checking of deviation angles, checking of levels at critical points. After completing the check survey, the tower spotting shall be carried out by the Contractor and profiles shall be submitted to the purchaser for final approval. The

Contractor shall be responsible for correct setting of stubs. Discrepancies, if any, shall be brought to the notice of purchaser and final approval shall be taken before execution of work.

(b) The requirement of tower site levelling and revetment work, if required, shall also be marked by the Contractor on the profiles while carrying out the detail or check survey work.

(c) If due to site conditions any change in the tower location/provision of extension is considered necessary compared to approve profiles, the contractor shall bring the same to the knowledge of the purchaser well in time and get revised approval of the profile before setting the stubs. The revised approval shall be conveyed to the Contractor by the Purchaser.

C. Soil Resistivity:-

While carrying out detailed/ check survey work, the Soil Resistivity values will have to be measured at convenient points along the route, not exceeding 2.50 Km between adjacent points. The Soil Resistivity will be measured using 4 electrode method with an inter electrode spacing of 50 M.

The following formula shall be used:

$$P = 2 \pi a R$$

Where a = Interelectrode spacing = 50M

R = Earth resistance measured in Ohms

P = Soil Resistivity in Ohm- m

The soil resistivity values shall be submitted duly marked on the route map and also in the form of statement. The quoted rates for detailed survey/ check survey work shall be inclusive of cost of measuring soil resistivity values along the proposed route and the contractor will not be paid separately for this work.

D. **RIGHT OF WAY (ROW)**

The contractor shall refer to chapter 2 of this bidding document for obtaining ROW.

36.2.2 SUB-SOIL INVESTIGATION

To ascertain soil parameters in various stretch, inter, the contractor shall carry out sub-soil investigation through reputed soil consultant as approved by the employer.

36.2.2.1 SCOPE OF WORK

The scope of sub-soil investigation covers execution of complete soil exploration for the transmission line under this contract including boring, drilling, collection of undisturbed soil sample where possible, otherwise disturbed samples, conducting laboratory test of soil samples to find out the various parameters as detailed in this specification and submission of detailed reports in 6 copies along with specific recommendation regarding suitable type of foundation for each bore-hole along with recommendation for soil improvement where necessary.

36.2.2.2 QUALIFYING REQUIREMENTS OF SOIL CONSULTANTS

The soil consultants shall provide satisfactory evidence concerning the following as and when asked for. That, he/they has/have adequate technical knowledge and previous practical experience in carrying out complete soil investigation jobs in any kind of soil. That he/they has/have well equipped, modernized soil testing laboratory of his/their own. If asked for by the employer, the contractor shall arrange inspection of such laboratory of the soil consultant by the representative of the employer. If in the opinion of the employer, the soil consultant (proposed by the contractor) is not well equipped or capable to undertake the sub-soil investigation job relating to this contract, then such soil consultant shall not be engaged to undertake the job. In that case, they shall have to engage other agency as will be approved by the employer.

36.2.3 TEST BORING

The boring shall be done at the major locations/crossing, special towers. However, it is desirable that there should be at least one sub-soil investigation bore-hole for the line. Such locations for sub-soil investigation shall be selected and finalized in consultation with the employer.

The test boring through different layers of all kinds of soil shall have to be carried out by the contractor through the approved soil consultant as briefed hereunder.

I. Method of boring, selection of sampling tubes, sampling, recording of boring, protection, handling, leveling of samples shall be done as specified in IS: 1892/1977, if any, after obtaining approval from the employer. The contractor/consultant shall furnish in the soil report in details, the equipment and method of boring actually adopted.

II. Depth of boring below ground level shall be 15 M. only unless continuous bedrock is encountered earlier. In case rock is encountered at any depth within 15 M. adequate study of rock and assessment of strength characteristics shall be done and recommendation shall be given.

III. Undisturbed soil samples shall be obtained for the initial 4M depths at every 1.5M interval and at change of strata. After these initial 4M depths, samples shall be obtained preferably at every 3M or where there is a change of strata, or as advised by the employer.

IV. In case collection of undisturbed samples becomes difficult/impossible detailed soil testing on remoulded soil samples is to be considered and reported in the soil report.

V. Standard penetration test as per IS: 2131 with latest amendment shall have to be conducted in different strata and recorded properly.

VI. The ground water table shall be recorded during boring operation and incorporated in the bore log. If possible, the position of the water table just after monsoon period be ascertained from local people and indicated in the report.

VII. Plate Load test shall have to be conducted at special tower location.

36.3.0 LABORATORY TESTS OF SOIL SAMPLES

The method and procedure of testing of soil sample to be followed shall be as per relevant IS codes. Adequate volume of test samples shall be collected from site. Ample shall be properly sealed immediately after recovery as specified in relevant IS code and transported carefully to laboratory for carrying out necessary laboratory tests to find out the following parameters of every samples. Data and time of taking of the sample shall be recorded in the test report.

1 Natural moisture content, Liquid limit, Plastic limit and Plasticity index.
2 Bulk, dry and buoyant density of soil.
3 Void ratio (e-long P curve shall be submitted)
4 Specific gravity.

5 Grain size distribution (Sieve analysis and hydrometer analysis)
6 Tri-axial and consolidation tests (consolidation undrained and consolidated drained as and when application in table, graph and drawing.
7 Permeability tests
8 Chemical tests for both water and soil samples at different layers.
9 Evaluation of safe bearing capacity at different strata for square footings shall be done for a maximum value of 25-mm. settlements.
10 At depts. From 3M to 10M be different strata.
11 Factor of safety shall be considered as 3 for evaluation of safe bearing capacity of soil.
12 Unconfined compression test for cohesive soil (=0) if encountered.

- **REPORT ON SUB-SOIL INVESTIGATION**

The contractor shall make analysis of soil samples and rock cores as collected by him in the field and approved by the employer as collected by him in the field and approved by him in the field and approved by the employer as well as field tests and laboratory tests. A comprehensive report shall have to be prepared by him, finally incorporating all the data collected in proper tabular forms or otherwise along with the analysis.

The 3(three) copies of report in the draft form shall be submitted for employer's approval. 6(six) copies of final report incorporation employer's comments, if any shall be submitted within 3(three) weeks after completion of this work.

Recommendations shall include but not be limited to the following items (a) to (p)

I. Geological information of the region.
II. Past observations and historical data, if available, for the area or for other areas with similar profile or for similar structures in the nearby area.
III. Procedure of investigations employed and field and field as well as laboratory test results.
IV. Net safe bearing capacity and settlement computation for different types of foundations for various widths and depths of tower.
V. Recommendations regarding stability of slopes, during excavations etc.
VI. Selection of foundation types for towers.
VII. Bore hole and trial pit logs on standard proforma showing the depths, extent of various soil strata etc.
VIII. A set of longitudinal and transverse profiles connecting various boreholes shall be presented in order to give a clear picture of the site, how the soil/rock strata are varying vertically and horizontally.
IX. Modulus of sub grade reaction from plate load test for pressure ranging up to 6 kg/cm. The recommended values shall include the effect of size, shape and depth of foundations.
X. Deformation modulus from plate load test in various test depth/stratification.
XI. Coefficient of earth pressure at rest.
XII. Depth of ground water table and its effect on foundation design parameters.
XIII. Recommendations regarding stability of slopes, during shallow excavation etc.
XIV. Whether piles are necessary or not. If piles are necessary, recommendation of depth, diameter and types of piles to be used.
XV. Recommendations for the type of cement to be used and any treatment to the underground concrete structure based on the chemical composition of soil and sub-soil water.

- **MEASUREMENT OF SOIL RESISTIVITY**

For the purpose of grounding design, soil resistance measurement shall be taken in the locations as stated under clause 1.0 above and based on which the value of soil resistance shall be derived. Wenner's four (4) electrode method shall be used for earth resistance measurement in accordance with the procedure and the calculation detailed in IS:3043 1987. At least 8(eight) test direction shall be chosen from the center of the locations to cover the whole site. The employer reserves the right to carry out separate soil investigation at his cost by engaging a separate agency for cross checking the result obtained by the contractor. In case the results are at variance, the soil parameters to be adopted for final design will be at the sole discretion of the employer and such will be binding upon the contractor.

IMP:-The material and services covered under these specifications shall be performed as per requirements of the relevant standards and codes referred hereinafter against each set of equipment and services. In case of a conflict between such codes and/or standards and the Specifications, the latter shall govern. Other Internationally acceptable standards which ensure equal or higher performance than those specified shall also be accepted.

SL. No.		**Indian Standards**	**Title**	**International & Internationally recognised Standards.**
1		IS 209-1979	Specification for zinc	ISO/R/752-1968 ASTM B6
2		IS 269-1976	Structural Steel (standard quality)	ISO/R/630-1967 CAN/CSA G40.21 BSEN 10025
3		IS 269-1976	Ordinary rapid hardening and low heat Portland cement	ISO/R/597-1967
4		IS 383-1970	Coarse and fine aggregates from natural sources for concrete	CSA A23.1/A23.3
5	a	IS 398-1982	Specification for aluminium conductor for overhead transmission purpose	IEC 1089-1991 Part I BS 215-1970
	b	IS 398-1982	Aluminium conductor galvanized steel reinforced	BS 215-1970 Part-II, IEC 1089-1919
	c	IS 398-1994	Aluminium alloy	BS 3242-1970
		Part-IV	stranded conductor	IEC 1089-1991 ASTM 8393M86
	d)	IS 398-1982 Part-V	Aluminium conduc- tor galvanised steel reinforced for Extra High Voltage (400kV and above)	BS 215-1970 IEC 1089-1991
6.		IS 278-1978	Specification for barbed wire.	ASTM A 121

7.		IS 406-1964	Method of chemical analysis of Zinc slab	
8.		IS 432-1966 (Part 1 & 11)	Mild steel and medium tensile bars and hard drawn steel wire for concrete reinforcement.	BS 4449 CSA G-30. BS 4482
9.		IS 456-1978	Code of practice for plain and reinforced concrete.	ISO 3893-977
10.		IS 731-1971	Porcelain insulators for overhead power lines with nominal voltage greater than 1000 Volts.	BS 136-1982 (Part-I & II) IEC 383-1993 (Part-I& II)
11		IS 800-1962	Code fo practice for use of structural steel ingeneral building construction	CSA S 16.1 BS 5950
12. a)	IS802-(2015) part 1/section 1		Code of practice for use of structural steel in overhead transmission Line: materials, loads and permissible stresses	IEC 826 ANSI/ASCE 10-90 (1991)BS 8100
b)	IS802-(2016) (Part-I/ section 2)		Code of practice for use of structural steel in overhead transmission line, fabrication, galvanising inspection and packing	ANSI/ASCE 10-90 (1991)
c)	IS 802-Part3		Code of practice for use of structural steel in over-head transmission lines towers: testing	ANSI/ASCE 10-90 (1991) (Part III) IEC 652
13 IS 1139-1966			Hot rolled mild steel, medium tensile steel hogh yield strength deformed bars for concrete reinforcements	CAN/CSA G30.18 ASTM A615 and BS 4449

14 IS 1367-1967	Technical conditions for threaded fastners	
15 IS 1489-1976	Portland pozzolana cement	ISO/R 863-1968
16 IS 1521-1972	Method of tensile testing of steel wires	ISO 6892-1984
17 IS 1573-1976	Electroplated coating of zinc on iron and steel	BS-1559-194
18 IS 1786-1966	Cold twisted steel bars for concrete reinforcement	
19 IS 1778-1980	Reels and drum for bare conductro	
20 IS 1893-1965	Criteria of earthquake resistant design of structures	IEEE 693
21 IS 2016-1967	Plain washers	ISO/R 887-1968 ANSI B18.22.1
21 IS 2071 Part-I-1974 Part-II-1974 Part-III-1976	Method of high voltage tesings	IEC 60
22 IS 2121 I. part II. Part-1981	Specification for conductor and earthwire accessories for overhead power lines	

	I. Part-I-1981 II. Part-II -1981 III. Part-III-1992 IV. Part-IV-1991	Armour rods, binding wires and tapes for conductors. Mid-span joints and repair sleeve for conductors.	
24.	IS 2131-1967	Method of standard penetration test for soils.	ASTM D 1 883

25.	IS 2551-1982	Danger notice plates	
26.	IS 2486	Specification for insulator fittings for overhead power lines with a nominal voltage greater than 1000 Volts.	
	Part-I	General requirements and tests.	BS 3288 IEC 1284
	Part-II	Dimensional requirements	IEC 120-1984
	Part-III	Locking devices	IEC 372-1984
27.	IS 2629-1966	Recommended practice for hot dip galvani-sing of iron and steel.	ASTM A123 CAN/CSA G 164 BS 729
28.	IS 2633-1972	Method of testing uniformity of coating of zinc coated articles.	ASTM A123 CAN/CSA G164
29.	IS 3043-1972	Code of practice for earthing(with amend-ment No.1 and 2).	

30.	IS 3063-1972	Single coil rectangular DIN 127-1970 section spring washers for bolts nuts,	
31.	IS 3188-1965	Dimensions for disc IEC 305-1978 insulators.	
32.	IS 4091-1967	Code of practice for ASCE/IEEE 691 design and construction of foundation for transmission line towers and poles.	
33.	IS 4826-1979	Galvanised coating on round steel wires.	IEC 888-1987 BS 443-1982
34.	IS 5358-1969	Hot dip galvanised coat-ings on fasteners.	CAN/CSG 164 ASTM A153
35.	IS 5613 (Part-II/Sec-1) -1985 (Part-III/Sec.1) -1989	Code of practice for design, installation and maintenance of overhead power lines	ANSI/ASCE 10-90(1991)

36.	IS 5613 (Part-II/Sec-2) -1985 (Part-III/Sec.2) -1989	Code of practice for design, installation and maintenance of overhead power lines (Section 2: Installation and maintenance)	
37.	IS 6610-1972	Specification for heavy washers for	
38.	IS 6639-1972	Hexagonal bolts for steel structure.	ISO/R 272-1968 ASTM A394 CSA B33.4
39.	IS 6745-1972	Methods for determination of weight of zinc coating of zinc	ASTM A90 ISO 1460
40.	IS 8263-1976	Method of radio interference tests on	IEC 437-1973 NEMA 107-1964
41.	IS 8269-1976	Method of switching impulse tests on HV	IEC 506-1975
42.	IS 8500-1977	Specification for weldable structural steel (medium and	BSEN 10025
43.	IS 9708-1980	Specification for Stock Bridge vibration dampers for overhead	
44.	IS 9997-1988	Aluminium alloy redraw	IEC 104-1987
45.		Hard drawn aluminium wires for overhead line	IEC 889-1987
46.		Thermal mechanical performance tests and mechanical performance	IEC 575-1977
47.		Salt fog pollution voltage	IEC 507-1991
48.		Residual strength of string insulator units of glass or ceramic material for overhead lines after mechanical	IEC 797-1984
49.		Guide for the selection of insu- lators in respect of polluted	IEC 815-1986

50.		Tests on insulators of ceramic material or glass for overhead lines with a nominal voltage greater than 1000 Volts.	IEC 383-1993 (Part I and II)
51.		Ozone test on elastomer	ASTM D-1171
52.	IS 1363	Hexagonal head bolts, screws and nuts of product Grade - C	
	Part - 1	Hexagonal head bolts	ISO 4016
	Part - 3	Hexagonal nuts	ISO 4034
53.	IS 1367	Technical supply conditions for threaded steel fasteners	
	Part III Part VI	Mechanical properties and test methods for bolts, screws and studs with full loadability Mechanical properties and test methos for nuts with full	ISO 898-1 ISO/DIS 898/II
54.		Indian Electricity Rules - 1956	
55.		Indian Electricity Act - 1910	
56.	IS 1498-1970	Classification and identification of soil for	
57.	IS 1888-1982	Method of load test on	
58.	IS 1892-1979	Code of practice for subsurface investigation for foundation	
59.	IS 2911-1979 (Part-I)	Code of practice for design and construction of pile foundations	
60.	IS 4453-1980	Code of practice for exploration by pits, trenches, drifts and shafts	
61.	IS 6935-1973	Method for determination of water level in a bore hole	

62.	IS 8009-1976 (Part-I)	Code of practice for calculation of settlement of foundation subjected to symmetrical vertical loads	
63.	IS 2386-1963 (Part-3)	Methods of test for aggregates for concrete : Specific gravity, density, voids, absorption and bulking	
64. 65.	IS 14000-1994	Quality management and quality assurance standards GRIDCO Safety Manual (draft)-1997	ISO 9000-1994
66.		Composite insulators for a.c. overhead lines with a nominal voltage greater than 1000 V : Definition,	IEC 1109-1992 ANSI C29-11 IEEE 987

CHAPTER 37: SPECIFICATION FOR DESIGN AND FABRICATION OF TRANSMISSION LINE TOWERS

37.1.1.0 SCOPE

37.1.1.1 This section covers the design, fabrication, galvanizing, supply and delivery, erection, testing and commissioning at site of galvanized steel structures, bolts & nuts, tower accessories etc. for transmission line towers covered under this Bid Document and as per Specification.

Single circuit stringing shall be made possible in the Double circuit towers for any voltage level.

37.1.2.0 GENERAL DESCRIPTION OF THE TOWER

37.1.2.1 General

37.1.2.1.1 The towers shall be of self-supporting hot dip galvanized lattice steel type designed to carry the line conductors with necessary insulators, earth wires and all fittings under all loading conditions.

37.1.2.1.2 The tower shall be fully Galvanised using mild steel or / and high tensile steel sections. Bolts and nuts with spring washer are to be used for connections.

37.1.2.2 Type of Towers

37.1.2.2.1 Normal Towers

The towers for transmission lines are classified as given below. The bidder shall design and quote for the following four types of towers (Standard/Standard Towers):

Tower type D shall also be used as a Dead-End tower.

Type of Deviation Typical Use

Tower Limit

Type of Tower	Deviation Limit	Typical Use
A	0 – 2 deg.	To be used as tangent tower with single or Double suspension Insulator String
B	2 - 15 deg.	a) Angle towers with Single / Double Tension insulator string.
C	15 - 30 deg.	a) Angle tower with single or /and double tension insulator string.
		b) Also to be used for locations where uplift exist. c) Section tower for anti cascading condition.
D	30 - 60 deg/ Dead End.	a) Angle tower with Single or / and Double tension insulator string.
		b) Also to be used for locations where uplift exist.

		c) Dead end with 0 deg. to 15 deg. deviation both on line side and sub station side (slack span)

Dead End. a) Angle tower with Single or / and Double tension insulator string.

b) Also, to be used for locations where uplift exist.

c) Dead end with 0 deg. to 15 deg. deviation both on line side and sub station side (slack span)

The angles of line deviation specified are for the design span. The span may however be increased up to an optimum limit with reduced angle of line deviation if adequate ground and phase clearances are available. For this purpose, the Contractor shall prepare a tower rating chart (weight/wind span as function of various angles of deviations).

37.1.2.2.2 Body Extensions Truncations & Unequal Leg Extensions Truncations

a) All Normal towers mentioned in Clause above shall be designed for 3, 6, 9, 12, 15- and 18-meter body extensions for maintaining adequate ground clearance as per the terrain, without reducing the safety margins available in normal towers in any manner. Towers which require more than 18 m extension shall be treated as Special Towers.

b) All above extensions to normal towers shall be treated as part of normal towers only.

c) Prices shall be quoted as per weight (in MT) basis on the guaranteed black weight of towers.

d) Designs and drawings of all type of towers with extensions as mentioned in (a) above along with foundations (all type) shall be submitted for approval of the employer irrespective of whether such requirements are there or not for a particular transmission line.

e) Attached as ANNEXURE: (Chapter: 34 (A))

37.1.2.2.3 Special Towers

The towers which will be specially designed for very long spans such as Major River crossings etc. that cannot be crossed by normal tower with extensions shall be special towers.

The Bidder must furnish design of each of these special towers for approval of the Employer. The Contractor shall quote for these towers separately at unit rates by weight per MT of super structure and fittings and will supply the same if so required.

37.1.3.0 SPANS AND CLEARANCES

37.1.3.1 **Normal span, Wind Span & Weight Span**

The normal ruling span, wind span and weight span to be adopted for lines covered under this Specification are specified in Annexure-1 of this section along with all other parameters.

37.1.3.2 **Electrical Clearances**

37.1.3.2.1 **Ground Clearance**

a) The minimum ground clearance of conductors above ground shall not be less than the limits specified in Line Data at Annexure I, at a conductor temperature of 95°C (for AAAC conductors) and 85°C (for ACSR conductors) and in still air. However, to achieve the above clearance the standard tower heights include the following additional allowances:

b) 150 mm sag errors in stringing;

c) Conductor creep as calculated by over tensioning the conductor at a temperature of 30°C lower than the stringing temperature or as determined from the sag-tension tables, which include the final sags including the effects of creep.

37.1.3.2.2 **Clearances of live parts form cross arm & towers**

The minimum clearances shall be adopted from the following Table.

SL No	Item	Swinging in degrees	Minimum electrical clearances for line voltage 132 kV	Minimum electrical clearances for line voltage 220 kV	Minimum electrical clearances for line voltage 400 kV
1	SUSPENSION STRINGS (a) Single suspension string	Nil	1530	2130	3050
		15°	1530	1980	3050
	(in mm)	30°	1370	1830	1860
		45°	1220	1675	-
		60°	1070	-	-
					3050
	(b) Double suspension	Nil			3050
	(c) Pilot Insualtor	15°	1530	2130	
2	Tension string Single/ Double	Nil	1530	2130	3050
3	Jumper	Nil	1530	2130	3050
		10°	1530	2130	3050
		20°	1070	1675	1860
		30°	1070	1675	-
4	Min vertical distance between conductor or X-arm (single/double circuit) (in mm)		3900	4900	8000
5	Min horizontal distance between conductors (single/ double circuit)(in mm)		6800	8400	15000
6	Mid span clearance (in mm)		6100	8500	9000

7	Ground Clearance (in mts)		6.1	7.015	8.84

37.1.3.2.3 **Railway Crossings, etc**

For railway crossing the clearances from the lowest conductor points to the rail level shall not be less than what is required to comply in all respects with the "Regulation governing the placing of transmission lines across railway tracks" issued by the railway board. In case of trunk road crossings, the clearance from the lowest conductor point to road level shall not contravene the provision of IE rules. Power and Tele-communication line crossings are to be constructed strictly in accordance with provision of IE Rules.

37.1.4.0 DESIGN DRAWINGS

37.1.4.1 The relevant drawings for all the towers and their extension shall be furnished by the Contractor to the Employer which shall include structural/erection drawings, shop fabrication drawings, Bill of Materials, foundation working drawings.

37.1.4.2 The structural/erection drawings, Bill of materials and shop fabrication drawings for all the towers and their extensions shall be submitted as specified in this Bid document. Documents shall be submitted in four copies and will be finally approved by the Employer. The mass/fabrication shall be taken up from the approved shop drawings. The overall responsibility of fabricating tower members correctly lies with the Contractor only and the Contractor shall ensure that all the tower members can be fitted while erecting without any undue strain on them.

37.1.4.3 The tower accessories drawings like name plate, danger plate, phase plate, anti climbing device, step bolt, D-shackle etc. shall also be prepared by the Contractor and shall be submitted to the Employer, in three copies, along with one reproducible, for record. These drawings shall be prepared in A4 size only.

37.1.4.4 All the drawings shall 'have a proper name plate clearly displaying the name of “Assam Electricity Grid Corporation Ltd ” on right hand bottom corner. The exact format of the nameplate shall be handed over to the successful bidder for incorporation of the same on all the drawings. Also, all the drawings shall carry the following statement and shall be displayed conspicuously on the drawing: **WARNING: THIS IS PROPRIETARY ITEM AND DESIGN RIGHT IS STRICTLY RESERVED WITH AEGCL. UNDER NO CIRCUMSTANCES THIS DRAWING SHALL BE USED BY ANYBODY WITHOUT PRIOR PERMISSION FROM THE EMPLOYER IN WRITING.**

37.1.4.5 While submitting the structural drawings, bill of materials and any other drawings pertaining to the subject transmission line, the Contractor shall clearly indicate on each drawing Bid Reference No., Name of the transmission line and project, letter reference no. and date on which the submission are made. The same practice is also to be followed while submitting distribution copies. The Contractor shall be required to submit 15 copies of all relevant drawings for necessary distribution.

37.1.5.0 SLENDERNESS RATIO

37.1.5.1 Slenderness ratio for members shall be computed in accordance with Clause 10 of IS: 802. The limiting values of L/R shall be as follows:

(a) Leg members, G.W. peak and cross arm lower member: 150

(b) Bracings: 150

(c) Redundant members and those carrying nominal stress: 250

(d) Tension member: 400

37.1.6.0 CONDUCTOR CONFIGURATION

37.1.6.1 In case of the double circuit line, the six power conductors shall be square type of formation. For, single circuit stringing on D/C towers, the three power conductors shall be in vertical line formation on one side, at distances suiting to the specified clearance requirements. Earth wire/OPGW shall be provided above the conductors at suitable distance to offer effective shielding and safe clearance.

37.1.7.0 HEIGHT AND LOCATION OF GROUND WIRES

37.1.7.1 Provision of single earth wire / ground wire shall be made in the design of the towers. The height and location of the ground wires will be such that the shield angle is not greater than 30 degrees and 20 degrees for 132KV/ 220 KV and 400 KV respectively (twin peak).

37.1.7.2 The mid-span clearance between the earth wire and conductors shall be kept more than the clearance at the tower. The Contractor shall maintain the sag of the ground wire at least 10 percent less than that of the power conductor under all temperature conditions in still wind at the normal spans so as to give a mid span separation greater than that at the supports.

37.1.8.0 LOADS ON TOWERS

37.1.8.1 The tower members shall be designed for three conditions of loadings. The conditions with their combinations of loadings are as follows:

A) **Reliability Condition (Normal Condition)**

i) Transverse Loads as per as per IS-802-2015, Part 1, sec 1

ii) Vertical Loads as per per IS-802-2015, Part 1, sec 1

iii) Longitudinal Loads as per IS-802-2015, Part 1, sec 1

B) **Security Condition (Broken wire condition)**

i) Transverse Loads as per IS-802-2015, Part 1, sec 1

ii) Vertical Loads as per IS-802-2015, Part 1, sec 1

iii) Longitudinal Loads as per IS-802-2015, Part 1, sec 1

C) **Safety Condition (Construction and Maintenance)**

a) **Normal Condition**

i) Transverse Loads as per IS-802-2015, Part 1, sec 1

ii) Vertical Loads as per IS-802-2015, Part 1, sec 1

iii) Longitudinal Loads as per IS-802-2015, Part 1, sec 1

b) **Broken Wire Condition**

i) Transverse Loads as per IS-802-2015, Part 1, sec 1

ii) Vertical Loads as per IS-802-2015, Part 1, sec 1

iii) Longitudinal Loads as per IS-802-2015, Part 1, sec 1

37.1.8.2 Transverse Loads: Reliability Condition (Normal Condition)

Under these following loads shall be taken into account:

a) Wind Load on Conductor and Ground Wire:

This shall be calculated by taking the basic wind pressure be acting normal to the line.

b) Wind Load on Insulator String:

Wind load on insulator strings shall be determined from the attachment point to the centre line of the conductor in case of suspension towers and up to the end of clamp in case of tension towers. The Design wind pressure shall be considered acting on 50% area of insulator string projected on a plan, which is parallel to the longitudinal axis of the string.

c) Wind Load on Towers:

This shall be calculated considering the wind to be acting normally on face of the tower.

d) Transverses Loads from Mechanical Tension of Conductors and Ground Wire (Due to line deviation):

This is the component of conductor/ground wire tension at tower acting in the transverse direction of the line. In calculating this force; the conductor/ground wire tension is either the tension at every day temperature (32˚C) &100% of full wind pressure or the tension at minimum temperature and 36% of full wind pressure whichever is more.

37.1.8.3 Transverse Loads: security condition

a) **Suspension Towers**

i. Transverse loads due to wind acting on tower structure, conductors, ground wires and insulators shall be taken as nil.

ii. Transverse loads due to line deviation shall be based on component of mechanical tension of conductors and ground wires corresponding to everyday temperature and nil wind condition. For broken wire the component shall be corresponding to 75% of mechanical tension of conductor and 100% of mechanical tension of ground wire at every day temperature and nil wind.

b) **Tension and Dead-End Towers**

i. Transverse loads due to wind action on tower structure, conductors, ground wire and insulators shall be as per Clause: 37.1.8.2 (a) and (b) 60% wind span shall be considered for broken wire and 100% for intact wires.

ii. Transverse loads due to line deviation shall be the component of 100% mechanical tension of conductor and ground wire as defined in Clause: 37.1.8.2 (d).

37.1.8.4 Transverse Loads: safety condition

a) **Normal Condition: -- Suspension, Tension and dead-End Tower**

i) Transverse loads due to wind action on tower structure, conductors ground wires and insulators shall be taken as nil.

ii) Transverse loads due to mechanical tension of conductor or ground wire shall be calculated in same manner as in Clause: 37.1.8.2 (d) but with tension corresponding to everyday temperature and nil wind.

b) **Broken Wire Condition: -- Suspension, Tension and dead-End Tower**

i) Transverse loads due to wind action on tower structure, conductors, ground wire, insulators shall be taken as nil.

ii) Transverse load due to mechanical tension of conductor or ground wire on account of line deviation shall be taken as follows:

$$TM = TI \times \sin \varphi/2, \text{ where,}$$

Where, TM = Load

TI = 50% of tension of conductor and 100% of tension of ground wire at everyday temperature and nil wind for suspension tower and 100% for angle and dead-end towers for both conductor and ground wire.]

Φ = Angle of deviation of tower.

37.1.8.5 Vertical Loads: Reliability Condition (normal condition)

i) Loads due to weight of each conductor and ground based on appropriate weight span, weight of insulator strings and accessories.

ii) Self weight of structures up to tower panel under consideration.

37.1.8.6 Vertical Loads: Security Condition

i) Loads due to weight of each conductor or ground wire based on appropriate weight span, weight of insulator strings and accessories taking broken wire condition where the load due to weight of broken conductor/ground wire shall be considered as 60% of weight span. For intact wire the vertical load shall be considered as given in Clause: 37.1.8.5.

ii) Self weight of structures up to tower panel under consideration.

37.1.8.7 Vertical Loads: Safety Condition

(i) Same as Clause 37.1.8.6 (i) multiplied by overload factor of 2.0

(ii) Same as Clause 37.1.8.6 (ii).

(iii) A load of 1500 N shall be considered acting at each cross-arm tip as a provision for weight of line man with tools.

(iv) An additional load of 3500 N at cross arm tip.

(v) All bracings and redundant members of the towers which are horizontal or inclined up to 150 from horizontal shall be designed to withstand as ultimate vertical load of 1500 N considered as acting at centre, independent of all other loads.

37.1.8.8 Longitudinal Loads: Reliability Condition

A) **Suspension and Tension Towers**

i) Longitudinal loads for Suspension and Tension towers shall be taken as nil.

ii) Longitudinal loads which might be caused on tension towers by adjacent spans of unequal length shall be neglected.

B) **Dead End Tower**

i) Longitudinal loads for Dead End Towers shall be considered corresponding to mechanical tension of conductors and ground wires at every day temperature & design wind pressure or at minimum temperature with 36% of design wind pressure, whichever is more stringent.

37.1.8.9 **Longitudinal Loads: Security Condition**

A) **Suspension Towers**

The longitudinal loads corresponding to 50% of the mechanical tension of conductor and 100% of mechanical tension of ground wire shall be considered under everyday temperature and no wind pressure for broken wire only.

B) **Tension Towers**

Horizontal loads in longitudinal direction due to mechanical tension of conductors and ground wire shall be taken for loading criteria mentioned in Clause: 37.1.8.8 (B) for broken wires. For intact wires these loads shall be considered nil.

C) **Dead End Towers**

Horizontal loads in longitudinal direction due to mechanical tension of conductors and ground wire shall be taken for loading criteria mentioned in Clause: 37.1.8.8 (B) for intact wires; however, for broken wires these loads shall be considered nil.

37.1.8.10 Longitudinal Loads: Safety Condition

A) **Normal Condition**

i) **Suspension and Tension Towers**

These shall be taken as nil.

ii) **Dead End Towers**

These loads for Dead End towers shall be considered as corresponding to mechanical tension of conductors/ground wire at every day temperature and nil wind. Longitudinal loads due to unequal spans may be neglected.

B) **Broken wire Condition**

i) Longitudinal loads during construction simulating broken wire condition will be based on stringing of one earth wire or one complete phase conductor at one time.

ii) **Suspension Towers**

Longitudinal loads during stringing on suspension towers should be normally imposed only by the passing restriction imposed during pushing of the running block through the sheave. It will apply only on one complete phase of sub-conductor or one earth wire. It will be taken as 10000 N per sub-conductor or 5000 N per earth wire.

iii) **Tension and Dead-End Tower**

Angle Towers used as dead end during stringing simulating broken wire condition shall be capable of resisting longitudinal loads resulting from load equal to twice the sagging tension (sagging tension is 50% of the tension at every day temperature and nil wind) for one earth wire or one complete phase sub- conductors which is in process of stringing. At other earth wire or conductor attachment points for which stringing has been completed, loads equal to 1.5 times the sagging tension will be considered.

37.1.8.11 Anti Cascading Checks

i) All angle towers shall be checked for the following anti-cascading conditions with all conductors and G.W. intact only on one side of the tower.

ii) Transverse Loads:- These loads shall be taken under no wind condition.

iii) Vertical Loads:- These loads shall; be the weight of conductor/ground wire intact on one side of tower, weight of insulator strings and accessories.

iv) Longitudinal Loads:- These Loads shall be the pull of conductor/ground wire at every day temperature and no wind applied simultaneously at all points on one side with zero-degree line deviation.

37.1.8.12 BROKEN WIRE CONDITIONS

A) **SINGLE CIRCUIT TOWERS**

Any one-phase conductor or earth wire broken, whichever is more stringent for a particular member.

B) **DOUBLE CIRCUIT TOWERS**

i) **SUSPENSION TOWERS**

Any one phase conductor or earth wire broken, whichever is more stringent for a particular member.

ii) **ANGLE TOWERS, TYPE-B & C**

Any two phases broken on the same side and same span or any one phase and one ground wire broken on the same side and same span whichever combination is more stringent for a particular member.

iii) ANGLE TOWERS, TYPE-D (Dead End Tower)

Any three phases broken on the same side and same span or any two phases and one ground wire broke on the same side and same span whichever combination is more stringent for a particular member.

37.1.9.0 DESIGN WIND PRESSURE

37.1.9.1 Design Wind Pressure for the purpose of this Specification shall be taken as 793 N/m2 which corresponds to wind velocity at 10 m height. For Design Wind Pressure at other heights reference shall be made to IS: 802 or ‘Transmission Line Manual’ published by Central Board of Irrigation and Power, New Delhi. The Design Wind Pressure mentioned above is corresponds to Wind Zone-5, Reliability Level-1 and Terrain Category-2 as per IS: 802.

37.1.10.0 OTHER DESIGN PARAMETERS

37.1.10.1 For other design parameters to be adopted for the design of towers reference shall be made to Annexure I of this Specification.

37.1.11.0 MATERIALS

37.1.11.1 **Tower Steel Sections**

37.1.11.1.1 IS Steel Sections of tested quality of conformity with IS:2062 (Designated Y.S. 250 MPa) or/and IS:8500 (Designated Y.S. 350 Mpa) are to be used in towers, extensions and stub setting templates. The Contractor can use other equivalent grade of structural steel angle sections and plates conforming to International Standards (IS-802(2015/P1 to 3) - Code of practice for use of structural steel in overhead transmission line towers). However, use of steel grade having designated yield strength more than that of EN 10025/BS-4360-50B grade (355MPa) is not permissible.

37.1.11.1.2 Steel plates below 6mm size exclusively used for packing plates/packing washers produced as per IS: 1079 (Grade -0) are also acceptable. However, if below 6mm size plate are used as load bearing plates viz gusset plates, joint splices etc. the same shall conform to IS: 2062 / BS : 4360 or equivalent standard meeting mechanical strength/metallurgical properties corresponding to Fe-410 or above grade (designated yield strength not more than 355MPa), depending upon the type of grade incorporated into design. The chequered plates shall conform to IS: 3502.

37.1.11.1.3 For designing of towers, preferably rationalized steel sections have been used. During execution of the project, if any particular section is not available, the same shall be substituted by higher section at no extra cost to Employer and the same shall be borne by the Contractor. However, design approval for such substitution shall be obtained from the Employer before any substitution.

37.1.11.2 Fasteners: Bolts, Nuts and Washers

37.1.11.2.1 All bolts and nuts shall conform to 18-12427. All bolts and nuts shall be galvanized as per IS: 1367 (Part-13)/18:2629 and shall have hexagonal head and nuts, the heads being forged out of the solid truly concentric, and square with the shank, which must be perfectly straight.

37.1.11.2.2 The bolt shall be of 16/24 mm diameter and of property class 5.6 as specified in IS: 1367 (Part-III) and matching nut of property class 5.0 as specified in IS: 136: (Part-VI).

37.1.11.2.3 Bolts up to M 16 and having length up to 10 times the diameter if the bolt should be manufactured by cold forging and thread rolling process to obtain good and reliable mechanical properties and effective dimensional control. The shear strength of bolts for 5.6 grade should be 31 0 MPa minimum as per IS: 12427. Bolts should be provided with washer face in accordance with 18:1363 (Part-I) to ensure proper bearing.

37.1.11.2.4 Nuts should be double chamfered as per the requirement of IS: 1363 Part-II'. It should be ensured by the manufacturer that nuts should not be overlapped beyond 0.4MM oversize on effective diameter for size up to M 16.

37.1.11.2.5 Fully threaded bolts shall not be used. The length of bolts shall be such that the threaded portion will not extend into the place of contact of the members.

37.1.11.2.6 All bolts shall be threaded to take the full depth of the nuts and threaded for enough to permit firm gripping of the members, but not further. It shall be ensured that the threaded portion of each bolt protrudes not less than 3 mm and not more than 8mm when fully tightened. All nuts shall fit tight to the point where the shank of the bolt connects to the head.

37.1.11.2.7 Flat and tapered washers shall be provided wherever necessary. Spring washers shall be provided for insertion under all nuts. These washers shall be steel electrogalvanised, positive lock type and 3.5mm in thickness for 16mm dia bolt and 4.5mm for 24mm bolt.

37.1.11.2.8 To avoid bending stress in bolts or to reduce it to minimum, no bolt shall connect aggregate thickness of members more than three (3) times its diameter.

37.1.11.2.9 The bolt positions in assembled towers shall be as per structural drawing.

37.1.11.2.10 Bolts at the joints shall be so staggered that nuts shall be tightened with spanners without fouling.

37.1.11.2.11 To ensure effective in-process Quality control it is essential that the manufacturer should have in house testing facility for all tests like weight of zinc coating, shear strength and other tests etc. The manufacturer should also have proper Quality Assurance System which should be in line with the requirement of this 5pecification and IS: 14000 series Quality System Standard

37.1.12.0 TOWER ACCESSORIES

37.1.12.1 Arrangement shall be provided for fixing of all tower accessories to the tower at a height between 2.5 meters and 3.5 meters above the ground level.

37.1.12.2 Step Bolts & Ladders

37.1.12.2.1 Each tower shall be provided with step bolts conforming to IS: 10237 of not less than 16mm diameter and 175mm long spaced not more than 450mm apart and extending from 2.5 meters above the ground level to the top of the tower. The step bolt shall be fixed-on one leg up to waist level and on two diagonally opposite legs above waist level up to top of the towers. Each step bolt shall be provided with two nuts on one end to fasten the bolt securely to the tower and button head at the other end to prevent the feet from slipping away. The step bolts shall be capable of with standing a vertical load not less than 1.5 KN.

37.1.12.2.2 For special towers, where the height of the super structure exceeds 50 meters, ladders along with protection rings as per approved design shall be provided in continuation of the step bolts on one face of the tower from 30 meters above ground level to the top of the special structure. From 2.5m to 30m height of super structure step bolts shall be provided. Suitable platform using 6mmthick perforated chequered plates along with suitable railing for access from step bolts to the ladder and from the ladder to each cross-arm tip and the ground wire support shall also to be provided. The platform shall be fixed on tower by using counter-sunk bolts.

37.1.12.3 Insulator Strings and Earth wire Clamps Attachments

37.1.12.3.1 Single / Double suspension insulator string assemblies shall be used for ‘A’ type tower as required. For the attachment of Suspension Insulator string, a suitable strain plate of sufficient thickness for transferring the load to the tower body shall be provided. To achieve requisite clearances, if the design calls for providing extra D-shackles, link plate etc. before connecting the 1nsulator string the insulator string the same shall be supplied by the Contractor.

37.1.12.3.2 At tension towers strain plates of suitable dimensions placed on the underside of each cross-arm tip, shall be provided for taking the hooks or D-shackles of the tension insulator strings. Full details of the attachments shall be provided to the successful bidder.

To achieve requisite clearances, if the design calls for providing extra D-shackles, link plate etc. before connecting the insulator string the same shall be supplied by the Contractor.

37.1.12.3.3 All important crossing like Railway Tracks, Important Roads, Rivers or any other Crossings of similar nature shall be done with Double Insulator String.

37.1.12.4 Earth wire Clamps Attachment

37.1.12.4.1 Suspension Clamp

The detailed drawing shall be submitted by the Contractor for Employer's approval. The Contractor shall also supply U- bolts, D-shackles wherever required.

37.1.12.4.2 Tension Clamps

Earth wire peaks of tension towers shall be provided with suitable plates to accommodate the shackle of tension clamps. The contractor shall also supply the U-bolts wherever required and take Employer's approval for details of the attachments before the mass fabrication.

37.1.12.5 Anti-climbing Device

Barbed wire type anti climbing device, as per IS 5613 shall be provided and installed by the Contractor for all towers. The barbed wire shall conform to IS-278 (size designation A 1). The barbed wires shall be given chromatin dip as per procedure laid down in IS: 160.

37.1.12.6 Danger, Number and Phase plate

Danger Plates, Number plates and phase plates shall be provided and installed by the Contractor.

a) Each tower shall be fitted with a danger plate, number plate and a set of phase plates. The transposition tower should have the provision of fixing phase plates on both the transverse phases.

b) The letters, figures and the conventional skull and bones of danger plates shall conform to IS-2551 and shall be in a signal red on the front of the plate.

c) The corners of the danger, number and circuit plates shall be rounded off to remove sharp edges.

d) The letters of number and circuit plates shall be red enameled with white enameled background.

37.1.12.7 Aviation Requirements

Aviation requirements, if indicated separately in Schedule of Requirements shall be in the scope of the Contractor and the same shall conform to IS: 5613.

37.1.13.0 TOWER FABRICATION

37.1.13.1 The fabrication of towers shall be in conformity with the following:

37.1.13.1.1 Except where hereinafter modified, details of fabrication shall conform to IS: 802 (Part-II) or the relevant international standards.

37.1.13.1.2 The tower structures shall be accurately fabricated to connect together easily at site without any undue strain on the bolts.

37.1.13.1.3 No angle member shall have the two leg flanges brought together by closing the angle.

37.1.13.1.4 The diameter of the hole shall be equal to the diameter of bolt plus 1.5mm.

37.1.13.1.5 The structure shall be designed so that all parts shall be accessible for inspection and cleaning. Drain holes shall be provided at all points where pockets of depression are likely to hold water.

37.1.13.1.6 All identical parts shall be made strictly inter-changeable. All steel sections before any work are done on them shall be carefully levelled, straightened and made true to detailed drawings by methods which will not injure the materials so that when assembled, the adjacent matching surfaces are in close contact throughout. No rough edges shall be permitted in the entire structure.

37.1.13.1.7 Minimum Thickness of Tower Members:

The minimum thickness of galvanised and painted tower members shall be as follows: -

ITEM	Minimum thickness in mm	
	Galvanised	Painted
Leg members & lower members of cross arms in compression	5	6
Other members	5	5

37.1.13.1.8 No tower angle member shall be less than 45x45x5 mm

37.1.13.2 Drilling and Punching

37.1.13.2.1 Before any cutting work is started, all steel sections shall be carefully strengthened and trued by pressure and not by hammering. They shall again be trued after being punched and drilled.

37.1.13.2.2 Holes for bolts shall be' drilled or punched with a jig but drilled holes shall he preferred. The punching may be adopted for thickness up to 16mm. Tolerances regarding punch holes are as follows:

a) Holes must be perfectly circular and no tolerances in this respect are permissible.

b) The maximum allowable difference in diameter of the holes on the two sides of plates or angle is 0.8mm. i.e. the allowable taper in a punched hole should not exceed 0.8 mm on diameter.

c) Holes must be square with the plates or angles and have their walls parallel.

37.1.13.2.3 All burrs left by drills or punch shall be removed completely. When the tower members are in position the holes shall be truly opposite to each other. Drilling or reaming to enlarge holes shall not be permitted.

37.1.13.3 Erection mark

37.1.13.3.1 Each individual member shall have erection mark conforming to the component number given to it in the fabrication drawings. The mark shall be marked with marking dies of 16mm size before galvanizing and shall be legible after galvanizing, 37.1.13.3.2 Erection Mark shall be A-BB-CC-DDD

A = Employer's code assigned to the Contractors -Alphabet

BB = Contractor's Mark-Numerical

CC = Tower Type Alphabet.

DDD= Number mark tube assigned by Contractor -Numerical.

37.1.14.0 QUANTITIES AND WEIGHTS

37.1.14.1 The quantities of the following items have been envisaged in Metric Tone (MT) in the relevant price Schedules for various types of towers:

i) Basic Body.

ii) Body Extensions.

iii) Stubs & Cleats

iv) Bolts & Nuts including spring washers and step bolts etc.

During detail engineering, proto assembly of each of the above items shall be inspected, Tested and approved by AEGCL and subsequently shall be released for fabrication and manufacturing as per the Technical Specification by the Contractor.

37.1.15.0 WEIGHTS OF TOWER

37.1.15.1 The Bidder shall furnish the guaranteed weights of each type of tower and stubs. The weight of tower shall mean the weight of tower, calculated by using the standard sectional weights of all steel members of the sizes indicated in the approved fabrication drawings and bill of materials without taking into consideration the reduction in weight due to drilling of bolt holes, skew cuts, chamfering etc. or increase in weight due to galvanizing but taking into considering the weight of the special fillings, bolts, nuts, washers etc.

37.1.15.2 After award of the contract, the bidder shall submit to the Employer for its approval, detailed design calculations and drawings for each type of tower. In case, the weight of the tower, finally approved and accepted by the Employer on the basis of the designs and drawings so submitted is more than the guaranteed weight, no extra amount shall be paid to the contractor.

37.1.15.3 If, however, the weight of the finally approved and adopted tower is less than the guaranteed weight, the payment shall be made on the basis of the finally accepted weights only.

37.1.15.4The contractor, while designing towers, shall use only such sizes of steel structures, which are easily procurable. If for any reason, the sections approved are not easily procurable, it is the responsibility of the contractor to procure the alternative sizes, which are satisfactory from the point of view of design, fabrication, galvanising and supply the same at no additional cost. The finally accepted weight shall mean the weight of each type of tower, design of which has been accepted.

37.1.16.0 STUB TEMPLATE

37.1.16.1 Stub templates shall be designed, and the Bidder shall quote unit rate for each type of tower. These stub templates shall be painted with two coats of red-oxide zinc chromate primer as per relevant IS.

37.1.17.0 GALVANIZING AND PAINTING

37.1.17.1 Galvanizing and painting of the various members of the structures shall be done only after all works of sawing, shearing, drilling, filing, bending and matching are completed. Galvanizing shall be done by the hot dip process as recommended in IS: 2629 or other such authoritative international standards and shall produce a smooth, clean and uniform coating of not less than 900 gm per square meter (130 microns). The preparation for galvanizing and the galvanizing process itself must not affect adversely the mechanical properties of the treated materials.

37.1.17.2 All assembly bolts shall be thoroughly hot dip galvanized after threading. Threads shall be of a depth sufficient to allow for the galvanized coating, which must not be excessive at the root of the threads, so that the nut shall turn easily on the completed bolts without excessive looseness. The nut threads shall not be galvanized, but oiled only.

37.1.17.3 The outside surface shall be galvanised. Sample of galvanised materials shall be supplied to the galvanising test set out in IS 729 or other such authoritative international standards.

37.1.17.4 The portion of the stub angle from 150 mm below the plinth level shall be black and the remaining portion shall be galvanised.

37.1.17.5 The parts, which are to be painted, shall be thoroughly cleaned. Two coats of a good quality primer shall be applied to produce a smooth void less surface before applying one coat of approved quality aluminium paint at works. The final coating of aluminium paint shall be applied after erection at site.

37.1.18.0 EARTHING

37.1.18.1 To keep provision in the towers for earthing, two holes of 17.5 mm diameter and about 50 mm apart shall be drilled on each of the legs of the towers, such that the lower hole is about 350 mm above the ground level, clear of the concrete muffing, for connecting the earthing strip.

37.1.19.0 TEST AND TEST CERTIFICATE

37.1.19.1 Each consignment ready for transportation shall be offered to the Employer for inspection before dispatch. Samples of fabricated tower materials shall be subjected to following tests: -

a. Tower steel: The structural steel shall conform to IS 226 and IS 8500, BS 4360-1068 or ISO / R 630 other such authoritative international standards. Manufacturer's test certificate shall be submitted for all used steel.

b. Galvanising: The galvanizing shall be as per IS 2633 or BS 729 other such authoritative international standards. Zinc coating over the galvanized surfaces shall not be less than 900 gm per square meter (130 microns).

c. Bolts and nuts: Manufacturer's test certificate as per standard practice shall be submitted.

37.1.19.2 Test at Contractor's Premise:

The contractor shall fabricate one specimen tower of each type as soon as possible after placement of order and before starting the bulk fabrication of the towers ordered. It shall be assembled on a foundation as nearly similar as practicable to site and tested with suitable test loads as per specified broken wire condition, multiplied by the corresponding factor of safety to ensure that the design and fabrication complies with the requirements. Each structure shall be capable of withstanding the above-mentioned tests without any injury or any permanent deflection at any part. If any member is found to be weak or damaged the design should be suitably modified and the tower re-tested.

After manufacture of first lot, finished members forming each type of towers shall be selected at random and tested for quality. The tower then shall be set on foundation as nearly similar as practicable to site and tested with equivalent test load for which the tower has been designed.

No tower or any member thereof, which failed under the test shall be supplied. No tests need to be carried out on the special towers and the 3 meter and 6 meter extensions. As such, they shall be very carefully designed on the basis of the results of the other types of towers.

If desired by the Employer, destruction test on towers shall be conducted. The Employer reserves the right to witness any and all of the tests carried out as above and so should be given 30 days advance notice of the dates on which such tests are scheduled to be carried out.

37.1.20.0 LIST OF STANDARDS AND GUIDES

List of Indian Standards and other related Publications

Sl. No	Indian Standards	Title
1	IS: 209-1992	Specification for Zinc
2	IS 278-1991	Galvanised Steel Barbed wire
3	IS 800-1991	Code of Practice for Steel in General Building Construction.
4	IS: 802 - 2015 (Part1, 2,3)	Code of Practice for use of Steel in Overhead Transmission Line
5	IS: 808-1991	Dimensions for Hot Rolled
6	IS: 875-1992	Coe of Practice for Design Loads (other than Earthquakes) for Buildings and Structures
7	IS: 1363-1990	Coe of Practice for Design Loads (other than Earthquakes) for Buildings and Structures
8	IS: 1367-1992	Technical Supply Conditions for Threaded Steel/ Fasteners
9	IS: 1477-1990	Code of practice for Painting of Ferrous Metals in Buildings
10	IS: 1573-199	Electro-Plated Coatings of zinc on iron and Steel
11	IS: 1852-1993	Rolling and Cutting Tolerances of Hot Rolled Steel Products
12	IS-1893-1991	Criteria for Earthquake Resistant Design of Structures
13	IS: 2016-1992	Plain Washers ISO/R887
14	IS:2062-1992	Steel for general structural purposes
15	IS: 2074-1992	Ready Mixed Paint. Air Drying Red Oxide, Zinc Chrome, Red Oxide, Zinc Chrome Priming Specification
16	IS:2551-1990	Danger Notice Plates
17	IS: 2629-1990	Recommended Practice for Hot Dip Galvanizing of iron and steel
18	IS: 2633-1992	Method of Testing Uniformity of Coating of Zinc Coated Articles
19	IS: 3043-1991	Code of Practice for Earthing
20	IS: 3063-1994	Single coil Rectangular section Spring Washers for Bolts, Nuts Screws
21	IS:3757-1992	High Strength Structural Bolts
22	IS: 4759-1990	Specification for Hot zinc coatings on structural steel and other Allied products
23	IS: 5369-1991	General Requirements for Plain Washers
24	IS:5613-1993	Code of Practice for Design installation and Maintenance of overhead Power Lines
25	IS:6610-1991	Specification for Heavy Washers for Steel structures
26	IS: 6623-1992	High Strength Structural Nuts
27	IS: 6639-1990	Hexagon Bolts for Steel Structure
28	IS: 6745-1990	Method for Determination of weight of Zinc coated iron and Steel Articles
29	IS: 8500-1992	Specification for Wieldable Structural Steel (Medium & High Strength Qualities)
29	IS: 10238-1989	Step Bolts for Steel Structures
30	IS: 12427-1988	Bolts for transmission Line Towers

31		Indian Electricity Rules
32	Publication No.19 (N)700	Regulation for Electrical Crossing of Railway Tracks
33	CBIP Publication No-	Transmission Line Manual

Annexure I

1.1.1 Basic System Data for Transmission Lines

SL. No	Description	132 KV	220 KV	400 KV
I	**II**	**III**	**IV**	**V**
1.	Nominal system voltage KV rms	132	220	400
2.	Highest system voltage KV rms	145	245	420
3.	System of grounding	Solidly Grounded	Solidly Grounded	Solidly Grounded
4.	Impulse insulation level KV peak	650	1050	1425
5.	Power frequency (wet) KV rms	260	460	650
6.	Protective shielding angle against direct lightning	NOT EXCEEDING 30^0	NOT EXCEEDING 30^0	NOT EXCEEDING 20^0
7.	Creepage Distance	27 mm/ KV	27 mm/ KV	27 mm/ KV
8.	Minimum Corona extinction voltage at 50Hz AC system Dry condition (phase to earth)	Not less than 154 kV	Not less than 156 kV	Not less than 320 kV

SL. No	Description	132 KV	220 KV	400 KV
I	II	III	IV	V
9.	Accessories for conductor and Earth wire	i. Preformed armour rods ii. Mid-Span compression joints iii. Repair sleeves iv. Flexible copper bonds v. Vibration dampers vi. Suspension clamps for earth wire vii. Tension clamp for earth wire		
10.	Insulator String Hardware	i. Anchor shackle ii. Chain link iii. Yoke plate iv. Ball clevis v. Arcing horn holding plate vi. Socket clevis vii. Arcing horns viii. Clevis eye ix. Free centre type/armour grip suspension clamp for suspension strings x. Compression type dead end clamp xi. Balancing weight		

1.1.2 Basic Design Parameters for 132KV TL

Item	Particulars	132 kV Line (Single/double-3phase) with AAAC	
1. SPAN	(i) Normal span (Design Span)	335 M	
	(ii) Wind span	335 M	
	(iii) Weight span, both span (total)	Suspension	Tension
	a) Maximum b) Minimum	505 M 185 M	505 M 0 M
	(iv) Weight span, one span	Suspension	Tension
	a) Maximum b) Minimum	315 M 100 M	315 M -200 M
2.Temparature Range		Conductor	Earth Wire
	(I) Maximum	85^0C	53^0C
	(ii) Minimum	0^0C	0^0C
	(iii) Every Day	32^0C	32^0C

Item	Particulars	132 kV Line (Single/double-3phase) with AAAC
3.Wind Speed Zone	Wind Speed Zone	Zone – 5 as per IS : 875
4. Conductor	(i) Material	AAAC Panther
	(ii) Number of strands & size	37/3.15 mm
	(iii) No. of conductor per phase	1
5.Ground Wire	(i) Type	OPGW
	(ii) Size	7 / 3.15 mm
	(iii) No. of earth wire	1
6. Wind Speed Zone	Wind Speed Zone	Zone – 5 as per IS : 875
7. Wind pressure	Maximum wind pressure up to a height of 10 M about mean retarding force	793 N/m^2
8.Ground Clearance (Under maximum sag)	(i) Rough country	6100 mm plus sag corrections
	(ii) Across and along all roads and paths	6100 mm Plus sag corrections & allowances
9. Insulators	(i) Type	Ball & Socket Type (16 mm for 90 kN disc &20 mm for 120 kN disc) / Long rod porcelain insulators
	(ii) Size of disc	255mm x 145 mm / as per IS 2486, IEC: 60120
	(i) Number of disc in each insulator (a) Suspension (b) Tension	 9 no. 10 no.
	(ii) Electro-mechanical strength (a) Suspension (b) Tension	 90 kN 120 kN
10. Tension Limits	(a) For conductor and ground wire (i) at 32^0 C &no wind (ii) at 32^0 C &full wind (iii) at 0^0 C &36% of full wind	 25 % of UTS 70 % of UTS 70 % of UTS

1.1.3 Basic Design Parameters for 220 KV TL

Item	Particulars	**220 kV Line (Single/double-3phase) with AAAC/ACSR**	
1. SPAN	(i) Normal span (Design Span)	350 M	
	(ii) Wind span	350 M	
	(iii) Weight span, both span (total)	Suspension	Tension
	c) Maximum	525 M	525 M
	d) Minimum	200 M	0 M
	(iii) Weight span, one span	Suspension	Tension
	c) Maximum	315 M	315 M
	d) Minimum	100 M	-200 M
2. TEMPARATURE RANGE	(I) Maximum	85^0C	
	(ii) Minimum	0^0C	
	(iii) Every Day	32^0C	
3. Wind Speed Zone	Wind Speed Zone	Zone – 5 as per IS : 875	
4. CONDUCTOR	(iv) Material	AAAC	
	(v) Number of strands & size	37/4.00 mm	
	(vi) No. of conductor per phase	1	
5. GROUND WIRE	(iv) Type	OPGW	
	(v) Size	7 / 3.15 mm	
	(vi) No. of earth wire	1	
6. Wind Speed Zone	Wind Speed Zone	Zone – 5 as per IS : 875	
7. Wind pressure	Maximum wind pressure up to a height of 10 M about mean retarding force	793 N/m^2	
8. GROUND CLEARANCE (Under maximum sag)	(i) Rough country	7000 mm plus sag corrections	

Item	Particulars	**220 kV Line (Single/double-3phase) with AAAC/ACSR**
	(ii) Across and along all roads and paths	7000 mm Plus sag corrections & allowances
9. INSULATORS	(i) Type	Ball & Socket Type (20 mm) / Porcelain long rod insulator
	(ii) Size of disc	255mm x 145 mm/ as per IS 2486 / IEC: 60120
	(iii) Number of disc in each insulator (c) Suspension (d) Tension	 14 no. 15 no.
	(iv) Electro-mechanical strength (c) Suspension (d) Tension	 90 kN 120 kN
10.Tension Limits	(b) For conductor and ground wire (iv) at 32^0 C & no wind (v) at 32^0 C & full wind (vi) at 0^0 C & 36% of full wind	 25 % of UTS 70 % of UTS 70 % of UTS

1.1.4 Basic Design Parameters for 400 KV TL

Item	Particulars	**400 kV Line (Single/double-3phase) with ACSR/AAAC**	
1. SPAN	(i) Normal span (Design Span)	400 M	
	(ii) Wind span	400 M	
	(iii) Weight span, both span (total)	Suspension	Tension
	e) Maximum f) Minimum	600 M 200 M	600 M 0 M
	(iii) Weight span, one span	Suspension	Tension
	e) Maximum f) Minimum	360 M 120 M	360 M -360 M
2.TEMPARATURE RANGE	(I) Maximum	85^0C	
	(ii) Minimum	0^0C	
	(iii) Every Day	32^0C	
3.Wind Speed Zone	Wind Speed Zone	Zone – 5 as per IS : 875	
4. CONDUCTOR	(vii) Material	ACSR Moose	
	(viii) Number of strands & size	54/3.53 mm Al 7/3.53 mm Steel	
	(ix) No. of conductor per phase	2	
5.GROUND WIRE	(vii) Type	Galvanised steel stranded wire, OPGW	
	(viii) Size	7 / 4 mm	
	(ix) No. of earth wire	2	
6. Wind Speed Zone	Wind Speed Zone	Zone – 5 as per IS : 875	
7. Wind pressure	Maximum wind pressure up to a height of 10 M about mean retarding force	793 N/m^2	
8.GROUND CLEARANCE (Under maximum sag)	(i) Rough country	8840 mm plus sag corrections	
	(ii) Across and along all roads and paths	8840 mm Plus sag corrections & allowances	

Item	Particulars	**400 kV Line (Single/double-3phase) with ACSR/AAAC**
9. INSULATORS	(i) Type	Ball & Socket Type (20 mm)/Porcelain long rod insulators
	(ii) Size of disc	255mm x 145 mm/ as per IS 2486 , IEC: 60120
	(v) Number of disc in each insulator (e) Suspension (f) Tension	 14 no. 15 no.
	(vi) Electro-mechanical strength (e) Suspension (f) Tension	 120kN 160 kN
10.Tension Limits	(c) For conductor and ground wire (vii) at 32^0 C & no wind (viii) at 32^0 C & full wind (ix) at 0^0 C & 36% of full wind	 25 % of UTS 70 % of UTS 70 % of UTS

CHAPTER 38: TOWER FOUNDATION FOR 220KV & 132KV TRANSMISSION LINES & PILE FOUNDATION

38.1.1.1 SCOPE

This section covers the specifications for design of foundations for various types of towers and special structures under different soil condition described herein after.

38.1.1.2 STANDARDS

For design of foundations reference shall be made to IS 4091 and relevant IS codes. Reference shall also be made to 'Transmission Line Manual' issued by Central Board of Irrigation and Power, New Delhi.

38.1.1.3 Foundations

Foundation includes supply of all labour, tools & machineries, excavation of soil, disposal and backfilling, formwork, shuttering & strutting, materials such as cement, sand, coarse aggregates and reinforcement steel and all associated activities, concreting, dewatering etc.

38.1.2 Type of Foundations

The foundation shall be of open cast type or as per BOQ. Plain Cement Concrete/Reinforced Cement Concrete footing shall be used for all type of normal towers. All the four footings of the tower and their extensions shall be similar for a particular location, except where soil condition and or water table are different at different legs. The total depth of foundation, below ground level shall be 3.0 to 3.5meters. For Hard Rock type and also where specific site conditions / properties demand foundation of different depths (lower or higher), the same shall be adopted.

38.1.3 TYPE OF FOUNDATION

38.1.3.1 Most of the paddy fields of Assam remain under water for more than 3 months in a year. During the remaining period of the year sub-soil water is normally found near the surface below the ground level. The Contractor shall note this factor while designing the foundation of towers.

38.1.3.2 It is expected that the type of foundations defined in following Clause shall be suitable for use at various locations of all the Transmission Lines covered in this Bid Document. The Contractor shall examine the suitability of the type of the foundation assigned for each location depending on the soil investigation reports and the same shall be approved by the Employer based on the suggested design of the foundation prepared as per the relevant soil investigation report. Under no circumstances the approved design shall be altered by the contractor nor the employer shall be under any obligation to approve a change in the design and employer is not liable for additional payement arising under that circumstances.

38.1.3.3 The Contractor shall design and quote for the following four types of foundations and all the foundations shall be RCC type.

(i) **Dry type foundation:** Design of this type of foundation shall be normally for dry / rocky / hard soil for which, (a) weight of earth shall be assumed to be 1600 kg/cum. (b) The Limit Bearing Capacity of the soil shall be 22000 kg/square meter. (c) The angle of repose shall be 30 deg.

(ii) **Wet type foundation (Suitable for paddy field location):** Design of this type of foundation shall be for locations where sub-soil water level is found below 1.5 meters from the ground level. This design shall also be suitable for paddy fields in Assam. The weight, the limit bearing capacity, the angle of repose and the ultimate bearing capacity of soil up to depth of 1.5 meter shall be taken as mentioned in (i) above and same for earth beyond 1.5-meter depth shall be taken as per (iv) below.

(iii) **Semi sub-merged type foundation:** Design of this type of foundations shall be for locations where sub-soil water level is found below 0.75 meter from the ground level. The weight, the limit bearing capacity, the angle of repose and the ultimate bearing capacity of soil up to depth of 0.75 meter shall be taken as mentioned in (i) above and same for earth beyond 0.75-meter depth shall be taken as per (iv) below.

(iv) **Sub-merged type foundation:** Design of this type of foundations shall be for locations where sub-soil water level is found at less than 0.75 meter from the ground level including completely sub-merged locations. (a) The weight of earth shall be assumed to be 850 kg/cum. (b) The limit bearing capacity of the soil shall be 11000 kg/sq. meter. (c) The angle of repose shall be 15°.

38.2.1 Design of Foundations

38.2.1.1 Design of foundations as classified under Cl. 38.1.3.1 for all towers and towers with extensions shall be developed by the Contractor based on their soil investigation report and approved thereof by Employer.

38.2.1.2 Depending on the site conditions other types of foundations shall also be designed suggested by the contractor suitable for Intermediate conditions under the above classifications to affect more economy or to suit specific site conditions encountered.

38.2.1.3 The proposal for these types of foundations shall be submitted by the Contractor based on the detailed soil investigation and duly approved by employer.

38.2.1.4 The pile foundations if required shall also be designed by the contractor based on detailed soil investigation report. The working drawing of these foundations shall be provided by the contractor to the employer prior to execution stage based on requirements.

38.2.2 Construction of Tower Foundation, Stub Setting and Earthing

38.2.2.1 Excavation

38.2.2.1.1 The excavation work for foundations shall be taken up by the contractor progressively stretch wise / section wise after obtaining approval from employer for the proposed stretch wise / section wise tower schedule, profile etc. as per detailed survey along the approved route alignment.

38.2.2.1.2 Except as specifically otherwise provided, all excavation for footings shall be made to the lines and grades of the foundations. The excavation wall shall be carried out considering the slope stability as well as ground water table. All excavation shall be protected so as to maintain a clean sub grade and provide worker safety until the footing is placed, using timbering, shoring, shuttering, dewatering etc. Contractor shall especially avoid disturbing the bearing surface of the pad. Any sand, mud, silt or other undesirable materials which may accumulate in the excavated pit or borehole shall be removed by Contractor before placing concrete.

38.2.2.1.3 The soil to be excavated for tower foundations shall be classified as follows depending upon the physical state of the soil at the time of excavation irrespective of the type of foundation installed.

a) Dry Soil

Soil removable either manually, by means of a spade and shovel or mechanically by proclaims, excavators etc. Excavation done in dry soil for wet, partially submerged, fully submerged and wet black cotton type of foundations shall also be covered under this.

b) Wet Soil

Where the subsoil water table is encountered within the range of foundation depth or land where pumping or bailing out of water is required due to presence of surface water shall be treated as wet soil. The excavation done in wet soil in case of wet, partially submerged, fully submerged and wet black cotton type of foundation shall also be covered under this.

c) Dry Fissured Rock

Limestone, laterite, hard conglomerate or other soft or fissured rock in dry condition which can be quarried or split with crowbars, wedges, pickaxes etc. However, if required, light blasting may be resorted to for loosening the material but this will not in any way entitle the material to be classified as hard rock.

d) Wet Fissured Rock

Above fissured rock, when encountered with subsoil water within the range of foundation depth or land where pumping or bailing out of water is required, shall be treated as wet fissured rock.

e) Hard Rock

Any rock excavation, other than specified under fissured rock above, for which blasting, drilling, chiseling is required. The unit rate quoted for hard rock excavation shall be inclusive of all costs for such drilling (including drilling required for anchoring), chiseling and blasting, etc.

38.2.2.1.4 No extra payment shall be admitted for the removal of fallen earth into a pit or borehole once excavated.

38.2.2.1.5 Where rock is encountered, the holes for tower footings shall preferably be drilled. Blasting where resorted to as an economy measure, shall be done with utmost care to minimise fracturing rock and using extra concrete for filling the blasted area. All necessary precautions for handling and use of blasting materials shall be taken. In cases where unnecessarily large quantities are excavated/blasted, resulting in placement of large volumes of concrete, payment of concrete shall be limited to design volumes of excavation, concreting, reinforcement etc. In case where drilling is done, the stubs may be shortened suitably with the approval of the Owner.

38.2.2.1.6 The Contractor shall arrange & supply requisite blasting material and permission from statuary body and be responsible for its storage and use, without any extra cost to the Owner.

38.2.2.1.7 Indian Standard IS:3764 snd relevant codes shall be followed regarding safety of excavation work.

38.2.3 **UNIT RATES AND MEASUREMENT FOR FOUNDATION**

38.2.3.1 The indicative shape of RCC foundations are enclosed in this Specification. The bidder is required to quote the unit rates for different foundation activity as a whole for geo-technical investigation, excavation for different types of soils, shuttering & shoring, concreting, backfilling, supply and placement of reinforcement steel, dewatering and all other incindential items for completion of the work.

38.2.3.2 The unit rates of RCC foundation for each type of soil shall include excavation along with all associated activities like shoring, shuttering, dewatering till completion of foundation work stock piling, dressing, back filling of foundations after concreting with excavated/borrowed earth (irrespective of lead) and consolidation of earth, carriage of surplus earth to the suitable point of disposal as required by the employer or any other activity required for to completion of foundation work in all respect.

38.2.3.3 Form boxes shall be used for casting of foundations. The unit rate of concreting shall include the cost of supply, fabrication and placement of form boxes, cement, water, coarse and fine aggregates mixing and placing of concrete, curing of concrete and any other activities related / required for completion of concreting works of foundation. The payment for this item shall be made as per the actual volumes of concreting completed but limited to design volume based on unit rates indicated in the letter of award.

38.2.3.4 The unit rate of RCC foundation shall include supply and placement of reinforcement steel, stirrups, wire for binding the reinforcement, chairs, bolsters and spacers etc. as required to complete the foundation work.

38.2.4 Setting of Stubs

38.2.4.1 The stubs shall be set correctly and precisely in accordance with approved method at the exact location, alignment and levels with the help of stub setting templates and levelling instruments. Stubs setting shall be done in the presence of Owner’s representative available at site where required and for which adequate advance intimation shall be given to Owner by Contractor. Tolerances as per provisions of IS:5613 shall be allowed for stub setting.

38.2.4.2 Setting of stub at each location shall be approved by Owner.

38.2.4.3 However, in hilly region for towers with unequal leg extensions and for river crossing towers, props may be used with complete accuracy and high skilled supervision, subject to prior approval from Owner.

38.2.4.4 For all towers the Contractor shall submit for approval the proposed method for setting of stubs.

38.2.5 Stub Setting Templates / Props

38.2.5.1 Stub setting templates shall be arranged by the Contractor at his own cost for all heights of towers. Stub templates shall be of adjustable type. The Contractor shall also arrange for props for setting of stubs at specific locations where use of prop is approved by the Owner. Stub templates / props should be painted.

38.2.5.2 The Contractor shall deploy sufficient number of templates / props for timely completion of the line without any extra cost to Owner.

38.2.5.3 However following minimum number of stub setting templates may be deployed by the Contractor for every 100km of line length subject to minimum of 5 templates for suspension tower.

Templates for tower type	Nos. to be deployed
i) A/DA	10
ii) For each type of B/DB, C/DC and D/DD type	3
iii) For A/DA +18/25 M	1
iv) for D/DD+18/25 M	1

However, if more templates are required for timely completion of the lines, the Contractor shall deploy the same without any extra cost to Owner. The number of sets of prop (if permitted) to be supplied, will depend as per actual site condition and completion schedule of line.

38.2.5.4 One set of each type of stub setting template / props (if used) shall be supplied to the Owner, on completion of the project, at no extra cost to Owner.

38.2.6 Mixing, Placing and Compacting of Concrete

38.2.6.1 The concrete shall be mixed in the mechanical mixer. However, in case of difficult terrain, hand mixing may be permitted at the discretion of the Owner. The water for mixing concrete shall be fresh, clean and free from oil, acids and alkalis. Saltish or blackish water shall not be used.

38.2.6.2 Mixing shall be continued until there is uniform distribution of material and mix is uniform in colour and consistency, but in no case the mixing be carried out for less than two minutes. Normal mixing shall be done close to the foundation but exceptionally, in difficult terrain, the concrete may be mixed at the nearest convenient place. The concrete shall be transported from the place of mixing to the place of final deposit as rapidly as practicable by methods which shall prevent the segregation or loss of any ingredient. The concrete shall be placed and compacted before setting commences.

38.2.6.3 To avoid the possibility of reinforcement rods being exposed due to unevenness of the bottom of the excavated pit, a pad of lean concrete 50mm thick and corresponding to a 1:3:6 nominal mix shall be provided at the bottom of the pad.

38.2.6.4 The concrete shall be laid down in 150mm layers and consolidated well, so that the cement cream works, up to the top and no honey-combing occurs in the concrete. A mechanical vibrator shall be employed for compacting the concrete. However, in case of difficult, terrain, manual compaction may permit at the discretion of the Owner. Monolithic casting of foundations must be carried out. However, in case of unavoidable circumstances, a key construction joint can be provided at the chimney-pad interface subject to approval of the Owner.

However, nothing extra shall be paid to the Contractor for providing such construction joints. After concreting the chimney portion to the required height, the top surface should be finished smooth with a slight slope towards the outer edge for draining rain water.

38.2.6.5 Wet locations shall be kept completely dewatered, both during and 24 hours after placing the concrete, without disturbance of the concrete.

38.2.6.6 If minor defects in concrete surface is found after the form work has been removed, the damage shall be repaired with a rich cement sand mortar to the satisfaction of the Owner before the foundation is back filled.

38.2.6.7 The concrete foundation for transmission line towers shall consists of two portions viz. (i) pyramid & (ii) chimney. In chimney portion, the thickness of the concrete cover should be such that it provides minimum cover of not less than 10 cm from any part of the stub angle to the nearest outer surface of the concrete in respect of all dry locations, limiting the minimum section of chimney to 30.5 cm. Sq. In respect of all wet locations, the section of chimney should be 45.72 cm. Sq. uniformly for all sizes of stub angle.

38.2.6.8 The chimney top or muffing must be 23 cm above ground level in dry locations, 38 cm in irrigated field and 15.24 cm above maximum water level in tank beds.

38.2.6.9 The size of the bottom portion of the foundation viz. Pyramid should be designed according to the nature of the sub soil met with at the design depth for the stub angles.

The maximum base thickness in the pyramid portion in case of sub-merged foundation may be taken as 200 mm.

38.2.7 Curing

The concrete shall be cured by maintaining the concrete wet for a period of at least 10 days after placing. Once the concrete has set for 24 hours the pit may be backfilled with selected moistened soil and well consolidated in layers not exceeding 200mm thickness and thereafter both the backfill earth and exposed chimney shall be kept wet for the remainder of the prescribed 10 days. The exposed concrete chimney shall also be kept wet by wrapping gunny bags around it and wetting the bags continuously during the critical 10 days period.

38.2.8 Backfilling and Removal of Stub Templates

38.2.8.1 After opening of formwork and removal of shoring, timbering, etc., backfilling shall be started after repairs, if any, to the foundation concrete. Backfilling shall normally be done with the excavated soil, unless it is a clay type or it consists of large boulders/stones, in which case the boulders shall be broken to a maximum size of 80-mm. At locations where borrowed earth is required for backfilling, Contractor shall bear the cost irrespective of leads & lift.

38.2.8.2 The backfilling materials shall be clean and free from organic or other foreign

materials. A clay type soil with a grain size distribution of 50% or more passing the no. 200 sieve are unacceptable for backfilling. The earth shall be deposited in maximum 200mm layers, levelled, wetted if necessary and compacted properly before another layer is deposited. The moisture content for compaction shall be based on the Proctor compaction test results given in the Geo-technical Report, Clause 3.0 of section III. The density of the compacted backfill material may further be verified to the satisfaction of the Owner based on the sand-cone method described in the ASTM D1556-82 standard.

38.2.8.3 The backfilling and grading shall be carried to an elevation of about 75mm above the finished ground level to drain out water. After backfilling 50mm high, earthen embankment (band) will be made along the sides of excavation pits and sufficient water will be poured in the backfilling earth for at least 24 hours. After the pits have been backfilled to full depth the stub template can be removed.

38.2.9 Benching

When the line passes through hilly/undulated terrain, levelling the ground may be required for casting of tower footings at no extra cost to the Employer. All such activities shall be termed benching and shall include cutting of excess earth and removing the same to a suitable point of disposal as required by Owner. Benching shall be resorted to only after approval from Owner. Volume of the earth to be cut shall be measured before cutting and approved by Owner for payment purposes.

Further, to minimise benching, unequal leg extensions shall be considered and provided if found economical. The proposal shall be submitted by the Contractor with detailed justification to the Owner.

38.2.10 Protection of Tower and Tower Footing

38.2.10.1 Tower shall be spotted such that the quantity of revetment are optimum. For tower locations in undulated terrain such as hill / mountain slopes, options like use of unequal leg extensions for towers, unequal chimney extensions etc. Shall be explored by the contractor for optimizing the need for revetment & benching.

38.2.10.2 The work shall include all necessary stone revetments, concreting and earth filling above ground level, the clearing from site of all surplus excavated soil, special measures for protection of foundation close to or in nalas, river bank / bed, undulated terrain, protection of uphill / downhill slopes required for protection of tower etc., including suitable revetment or galvanised wire netting and meshing packed with boulders. The top cover of stone revetment shall be sealed with M-15 concrete (1:2:4 mix). Contractor shall recommend protection at such locations wherever required. Details of protection of tower/tower footing are to be prepared by contractor duly approved by Employer.

38.2.10.3 Tower footings shall generally be backfilled using soil excavated at site unless unsuitable for backfilling. In the latter case, backfilling shall be done with borrowed earth of suitable quality irrespective of leads and lift. The unit rate for backfilling quoted shall include the required lead and consolidation and levelling of earth after backfilling.

38.2.10.4 The quantities for protection work of foundations are provisional only. The unit rates shall also be applicable for any quantity variations during execution. The same unit rates shall hold good for protection work carried out on down hills or up hills slopes applicable for the tower locations.

38.2.10.5 The unit rates for random rubble masonry revetment quoted in price schedule shall also include excavation & (1:6) random masonry and unit rate for top sealing with M-15 concrete. For payment purposes the volume of random rubble masonry revetment shall be measured from bottom to top sealing coat and paid at the unit rates indicated in the Letter Of Award. No extra payment shall be made for allied works such as excavation for revetment, packed stone at head of weep holes etc. However, no deduction shall be made for the volume enclosed by weep holes.

38.2.10.6 For some of the locations in nalas, river bed or undulated terrain etc., boulders of minimum. 150mm size bounded and packed in galvanised wire net/mesh of 8 SWG wire and 152 square (maxm.) mesh are to be provided. These stones shall be provided in crates size of 2.0mx2.0m or as deemed suitable for a particular location. Measurement shall be taken in cubic meters and 15% deduction will be made for void from cage/stack measurements.

38.2.11 SEISMIC CONDITION

Each foundation shall be provided with the tie beam for each type of tower to take care of seismic conditions. Force due to earthquake shall be assumed to be vertical 0.1g and horizontal 0.2g.

38.2.12 OVER LOAD FACTOR

The magnitude of limit loads for foundation should be taken as 10% higher than those of the corresponding towers.

38.2.13 LOADS ON FOUNDATIONS

38.2.13.1 The foundation shall be designed to withstand the loads of the superstructure for the full footing reactions obtained from the structure as per analysis in conformity with the relevant factors of safety. The reactions on the footings shall be composed of the following types of loads for which they shall be required to be checked.

1. Maximum tension or uplift
2. Maximum compression of down thrust
3. Maximum horizontal shear or side thrust

38.2.13.2 The additional weight of concrete in the footing below ground level over the earth weight and the full weight of concrete above the ground level in the footing and the embedded steel parts will also be taken into account adding to the down thrust.

38.2.14 GUARANTEED VOLUME OF FOUNDATIONS

38.2.13.1 The Bidder shall furnish guaranteed volumes of concreting and re-enforcement rods for each type of foundation for each type of towers along with their bids

38.2.13.2 For the purpose of evaluations and comparisons, these guaranteed volumes shall be taken into consideration and the different types of foundations.

38.2.13.3 After award of the contract, the bidder shall submit to the Employer for its approval, detailed design calculations and drawings for each type of foundation. In case, the volume of the foundation, finally approved and accepted by the Employer on the basis of the designs and drawings so submitted is more than the guaranteed volume, no extra amount shall be paid to the contractor. If, however, the volume of the finally approved and adopted foundation is less than the guaranteed volume, the payment shall be made on the basis of the finally accepted volume only.

38.2.13.4 The contractor may be asked at any time during the execution of the works to submit designs for special types of foundations for different towers in different locations if required.

38.3 CONSTRUCTION OF BORED CAST IN-SITU-PILE FOUNDATION

38.3.1 General Requirement

38.3.1.1 The specification covers the technical requirements for piling work, general description of work, quality and workmanship. In every case, work shall be carried out to the satisfaction of the Employer in accordance with the Technical Specifications and conform to location, lines, grades and cross sections shown on the construction drawing or as directed by the Employer. The specifications are not, however, intended to cover all the minute details and the work shall be executed according to the specified Indian Codes. Work shall be executed according to the IS Codes, best prevailing local Public Works Department practice or to the recommendations of the relevant International Standards or to the instructions of the Employer. This specification shall have precedence in case anything contrary to this is stated anywhere in this Bid Document. In case of conflict between the Specification and Codes, the former shall prevail.

38.3.1.2 The work shall include mobilization of all necessary equipments, providing necessary engineering supervision through qualified and technical personnel, skilled and unskilled labour, etc. as required to carry out the complete piling work. The minimum capacity of some key equipments are listed below. However, bidder has to furnish information regarding the equipments they intend to deploy for the project.

Sl.No.	Description	Capacity
1.	Tripod height	6m. to 10m. (clear drop)
2.	Rig (winch)	capacity 3 T to 5T
3.	Weight of chisel	2T to 3T
4.	Mud pump	capacity 15 HP to 25 HP
5.	Dia. of outlet pipe for bentonite	2.5 inch
6.	Rotary drilling rig Minimum torque (Hydraulic) along with all accessories	12T

Note: Bidder may have to provide higher capacity equipments than mentioned above, as per the actual requirement for the execution of the job, without any additional financial implication to AEGCL.

38.3.2 Layout and Levels

38.3.2.1 Layout and levels of structures etc. shall be made by the Contractor, at his own cost, from the general grid of the plot and the bench marks given by the Employer. The Contractor shall make his own arrangements, at his own cost, for locating the co-ordinates and position of piles as per approved drawings and for determining the Reduced Level (R.L.) of the locations with respect to the single bench mark indicated by the Employer. The Contractor shall provide at site all the required survey instruments, materials and men to Employer for verification of the detailed layout and correctness of the layout and levels to the satisfaction of the Employer so that the work can be carried out accurately according to specifications and drawings. The contractor shall be solely responsible for the correctness of layout and levels.

38.3.3 Site Preparation

This section of the specification covers site preparation of the areas as indicated in the drawings.

38.3.3.1 Reference Points and Bench Marks

38.3.3.1.1 Permanent reference pillars have to be established and under no circumstances shall the Contractor remove or disturb any permanent mark without the approval of the Employer. The Contractor shall carefully maintain and protect all bench marks and reference points and shall layout all his work by accurate reference thereto. The Contractor shall remove all vegetation, excluding trees, from the site areas as directed by the Employer.

38.3.3.1.2 The area shall be stripped to remove roots of grass, rubbish and slush, shrubs or other organic materials. Spoiled materials shall be burnt or removed to approved disposal areas on or near the job site as directed by the Employer.

38.3.4.0 **Properties of Construction Materials**

This clause specifies the properties of common building materials unless otherwise mentioned in the drawings or schedule of items. All materials viz., cement, steel, aggregates, water etc. which are to be used for pile construction are detailed below. However, aggregates more than 20mm shall not be used, except for lean concrete.

38.3.4.1 Coarse aggregates/Stone

38.3.4.1.1 All coarse aggregates shall be as per IS:383 consisting of hard, strong, compact grained and durable pieces of crushed stone having uniform in texture and colour and free from decay, flaws, veins, cracks and sand holes. Coarse aggregates should be of angular shape & rectangular surface and shall be free from organic or clay coatings and other impurities like disintegrated stones, soft flaky particles, adherent coatings, clinkers, slag, mica and any other materials liable to affect the strength, durability or appearance of concrete. The surface of a freshly broken stone shall be bright, clean, and free from any dull, chalky or earthy appearance. Coarse aggregates with round surface shall not be used. A coarse aggregate shall not absorb more than 5% of its weight of water after 24 hours immersion. Samples shall be submitted by the Contractor and approved samples shall be retained by the Employer for comparison of bulk supply.

38.3.4.1.2 Sieving and washing of aggregates by approved method shall be carried out wherever required**.**

38.3.4.1.3 Grading of coarse aggregate shall generally conform to IS:383 and shall be such as to produce a dense concrete of the specified proportions and strength and of consistency that will work readily into position without segregation.

38.3.4.1.4 The maximum size of aggregate shall be as follows unless specified otherwise:

i) Reinforced concrete with very narrow space - 10mm.

ii) Reinforced concrete & Plain Concrete - 20mm.

iii) Lean Concrete M15 -40mm.

38.3.4.2 Cement

Cement used shall generally be ordinary Portland Cement conforming to the Indian Standard Code IS:8112 or IS:12269. Alternatively, other varieties of cement other than ordinary Portland Cement such as Portland Pozzolana Cement conforming to IS;1489 or Portland Slag Cement conforming to IS:455 can also be used. The Contractor shall submit the manufacturer’s Test certificate, for each consignment of cement procured, to the Employer. However, Employer reserves the right to direct the Contractor to conduct tests for each batch/lot of cement used by the Contractor and Contractor will conduct those tests free of cost at the laboratory so directed by the Employer. The Contractor shall also have no claim towards suspension of work due to time taken in conducting tests in the laboratory. Changing of brand or type of cement within the same structure shall not be permitted without the prior approval of the Employer. Sulphate Resistant Cement shall be used if Sulphate content is more than the limits specified in IS:456, as per Geotechnical investigation report and as mentioned in the construction drawing. No additional payment shall be made for using Sulphate Resistant Cement.

38.3.4.3 Sand

Sand shall be hard, durable, clean and free from any adherent coatings or organic matter and shall not contain clay balls or pellets. The sand shall be free from impurities such as iron pyrites, alkalis, salts, coal, mica, shale or other laminated materials, in such forms or quantities as to affect adversely the hardening, strength, durability or appearance of concrete or to cause corrosions to any metal in contact with such concrete. In no case the cumulative percentage of impurities in sand shall be more than 5% by weight. All sand shall be properly graded. Unless otherwise directed by the Employer all sand shall pass through IS Sieve no. 2.36 mm. Sand for concrete shall conform to IS:383.

38.3.4.4 Water

Water shall be clean, fresh and free from organic matters, acids or soluble salts and other deleterious substances which may cause corrosion, discoloration, efflorescence etc. Potable water is generally considered fit for use. Water to be used shall comply with the requirements of IS:456 . Average 28 days compressive strength of at least three 15 cm. cubes of concrete prepared with proposed water shall not be less than 90% of average strength of three similar cubes prepared with distilled water. PH of water shall generally be not less than 6.

38.3.4.5 Reinforcement

Reinforcement steel shall be clean and free from loose mill scales, dust, loose rust, oil and grease or other coatings which may impair proper bond. Reinforcement shall be of epoxy coated complying the appropriate Indian Standards from Primary Producer e.g TATA Steel, SAIL, Jindal, RINL, or equivalent as per IS 13620:1993 or latest version. All steel bars including and above 6mm diameter shall be of tested for quality. Substitution of reinforcement, other than those mentioned above, shall not be permitted without the prior approval of the Employer.

38.3.5.0 Storage & Handling of construction Materials

All materials shall be stored by the Contractor in a manner aiding convenient access for identification and inspection at all times. The storage arrangements shall be subject to the approval of the Employer. Storage of materials shall be as described in IS:4082 .All materials shall be so stored as to prevent deterioration or intrusion of foreign matter and to ensure the preservation of their quality and fitness for the work. Any material which has deteriorated or has been damaged or is otherwise considered defective by the Employer shall not be used for concrete, and shall be removed from site immediately, failing which, the Employer will get the materials removed and the cost thereof shall be recovered from contract price. The Contractor shall maintain up to date accounts of receipt, issue and balance (stock wise) of all materials.

38.3.5.1 Cement

The cement shall be stored in dry enclosed shed, well away from the walls and insulated from the floor to avoid contact with moisture. The cement shall be stacked in easily countable stacks to facilitate removal of first in first out basis. The cement bags shall be gently kept on the floor to avoid leakage of cement from the bags. Sub-standard or partially set cement shall be immediately removed from the site as soon as it is detected. Cement stored for period beyond 90 days shall be tested before use.

38.3.5.2 Coarse Aggregates and Sand

All coarse aggregates & sand shall be stored on brick soling or an equivalent platform so that they do not come in contact with dirt, clay, grass or any other injurious substance at any stage. Aggregate of different sizes shall be kept in separate and easily measurable stacks. If so desired by the Employer, aggregates from different sources shall be stacked separately with proper care to prevent intermixing.

38.3.5.3 Reinforcement

Reinforcement steel shall be stored consignment wise and size wise, off the ground and under cover. It shall be protected from rusting, oil grease and distortions. If directed by the Employer, the reinforcement steel may have to be coated with cement wash before stacking, to prevent scale and rust at no extra cost to the Employer. The stacks shall be easily measurable. Only steel needed for immediate use shall be removed from storage. Fabricated reinforcement shall be carefully stored to prevent damage, distortion, corrosion & deterioration.

38.3.6.0 Cement Concrete

38.3.6.1 **General**

38.3.6.1.1 This section of the specification deals with cement concrete, plain or reinforced, and covers the requirement for concrete mix design, strength and quality, pouring at all levels, forming, protection, curing finishing, admixtures, inserts and other miscellaneous works.

38.3.6.1.2 The provisions of IS:456 shall be complied with, unless permitted otherwise. Any other Indian Standard Code shall form the part of the specification to the extent it has been referred to or applicable within this specification.

38.3.6.1.3 The Contractor shall furnish all labour, material and equipment to form, place and finish all structural concrete, concrete works and miscellaneous items complete, as described herein.

38.3.6.2 Admixtures

38.3.6.2.1 The admixtures in concrete for promoting workability, improving strength or for any other purpose, shall be used only after the written permission from the Employer. The Admixtures shall conform to IS:9103.

38.3.6.2.2 Admixtures should not impair durability of concrete nor combined with the constituent to form harmful compounds nor increase the risk of corrosion of reinforcement.

38.3.6.2.3 Addition of admixtures should not reduce the specified strength of concrete in any case. The workability, compressive strength and the slump loss of concrete with and without the use of admixtures shall be established during the trial mixes before use of admixtures.

38.3.6.2.4 The chloride content of admixtures shall be independently tested for each batch before acceptance.

38.3.6.2.5 If two or more admixtures are used simultaneously in the same concrete mix, data shall be provided to assess their interaction and to ensure their compatibility.

38.3.6.2.6 In case admixtures are used in the concrete for any structure, fresh mix design be done considering the admixture with the specific approval from Employer. No extra payment shall be made to the Contractor on this account.

38.3.6.3 Grades of Concrete

38.3.6.3.1 The minimum grade of concrete to be used for piling shall be **M-25** with minimum cement content 400 kg/m3 and maximum water cement ratio of 0.5. Concrete shall conform to the controlled design mix as specified in IS:456 . In addition, nominal mixes of 1:3:6 and 1:4:8 (with aggregates of nominal size 40mm maximum, by weight converted to equivalent volume shall also be used as per field quality plan. The concrete in aggressive surroundings due to presence of sulphate, etc., shall confirm to IS:456.

The slump of concrete shall be maintained between 150 to 200 mm.

38.3.6.3.2 The Contractor shall carry out concrete mix design in accordance with IS:10262 and submit mix design calculations and get them approved from the Employer well in advance of installation of pile foundations. The Contractor shall carry out adequate number of tests in accordance with IS:456 to ensure concrete of the minimum specified strength at requisite workability(i.e.slump).

38.3.6.4 Workmanship

All workmanship shall be according to the current Industry standard and best practices. Before starting a pour, the Contractor shall obtain the approval of the Employer in a “Pour Card” maintained for this purpose. He shall obtain complete instructions about the material and proportions to be used, Slump / workability, Quantity of water per unit weight of cement, number of test cubes to be taken, type of finishing to be done, any admixture to be added, any limitation on size of pour and stopping of concrete in case of premature stopping of pours.

Mixing of Concrete

38.3.6.4.1 All design mix concrete shall be mixed in mechanically operated mixer of an approved size and type capable of ensuring a uniform distribution on the materials through the mass. However, contractor can also use central batching plant situated within the area allocated for the Contractor’s particular use.

38.3.6.4.2 The proportions of sand, coarse aggregate, cement and water shall be as determined by the mix design. However, in case of nominal mix concrete (for lean concrete only) the proportions of sand, coarse aggregate, cement and water shall be fixed. The proportions, as determined for design mix concrete and shall always be approved by the Employer. The quantities of the cement, sand and coarse aggregates shall be determined by weight.

However, for a faster progress at site, quantities of the cement, sand and coarse aggregates can be converted to equivalent volume. The water shall be measured accurately after giving proper allowance for surface water present in the aggregate for which regular check shall be made by the Contractor.

38.3.6.4.3 The water shall not be added to the mix until all the cement and aggregates consisting the batch are already in the drum and dry mixed for at least one minute. Mixing of each batch shall be continued until there is a uniformity in colour and consistency but in no case shall mixing be done for less than two (2) minutes and at least forty (40) revolutions after all the materials and water are in the drum. When absorbent aggregates are used or when the mix is very dry, the mixing time shall be extended as may be directed by the Employer. Mixers shall not be loaded above their rated capacity as it prevents thorough mixing. If there is segregation after unloading from the mixer the concrete should be remixed.

38.3.6.4.3 The entire contents of the drum shall be discharged before the ingredients for the next batch are fed into the drum. No partly set or remixed or excessively wet concrete shall be used and it shall be immediately removed from site. Each time the work stops, the mixer shall be thoroughly cleaned and when the next mixing commences, the first batch shall have 10% additional cement at no extra cost to the Employer to allow for loss in the drum.

38.3.6.5 Conveying Concrete

Concrete shall be handled and conveyed from the place of mixing to the place of final laying as rapidly as practicable, by approved means, before the initial setting of the cement starts. Concrete should be conveyed in such a way as will prevent segregation of Concrete which may occur during transportation of concrete. In case of any such segregation during transport, the concrete shall be re-mixed. During very hot or cold weather, if directed by the Employer, concrete shall be transported in deep containers, having mortar leak proof, which will reduce the rate of water loss by evaporation and loss of heat. Conveying equipments for concrete shall be well maintained and thoroughly cleaned before commencement of concrete mixing. Such equipment shall be kept free from set concrete.

38.3.6.6 Placing of Concrete

a) Formwork and placement of reinforcement shall be approved in writing by the Employer before concrete is placed. The forms shall be well wetted and oil shavings, dirt and water that may have collected at the bottom shall be removed before concrete is placed. Concrete shall be deposited in its final position without segregation, rehandling or flowing. The interval between adding the water to the dry materials in the mixer and the completion of the final placing inclusive of compaction of the concrete shall be well within the

initial setting time for the particular cement in use or as directed by the Employer. As far as possible, concrete shall be placed in the formwork by means approved by the Employer and shall not be dropped from a height or handled in a manner which may cause segregation. Any drop over 1800 mm shall have to be approved by the Employer. Once the concrete is deposited in its final position, it shall not be disturbed. Care should be taken to avoid displacement of reinforcement or movement of formwork.

b) The placing of concrete shall be a continuous operation with no interruption in excess of 30 minutes between the placing of continuous portions of concrete.

c) After the concrete has been placed it shall be spread and thoroughly compacted by approved mechanical vibration to a maximum subsidence without segregation and thoroughly worked around reinforcement or other embedded fixtures into the correct form and shape. Vibrators shall not be used for pushing and shovelling concrete into adjoining areas. Vibrators must be operated by experienced men and over-vibration shall not be permitted. Head tamping in some case may be allowed subject to the approval of the Employer. Care must be taken to ensure that the inserts, fixtures, reinforcement and form work are not displaced or disturbed during placing of concrete. No concrete shall be placed in open while it rains. If there has been any sign of washing of cement and sand, the concrete shall be entirely removed immediately. Suitable precautions shall be taken in advance to guard against rains before leaving the fresh concrete unattended. No accumulation of water shall be permitted on or around freshly laid concrete. Tie beams, pile caps, footings shall be poured in one operation normally, in special circumstances with the approval of the Employer these can be poured in horizontal layers not exceeding 500 mm in depth. When poured in layers, it must be ensured that the under layer, is not already hardened. Blending of under layer if any, shall be effectively removed.

d) Wherever vibration has to be applied externally the design of formwork and the disposition of vibrators shall receive special consideration to ensure efficient compaction and to avoid surface blemishes.

38.3.6.7 Inserts

All anchors, anchor bolts, inserts, etc. and any other items those are required to be embedded in the concrete shall be placed in correct position before pouring. Extra care shall be taken during pouring

operation to maintain their position as indicated in the drawings. These inserts shall be welded to the nearest reinforcement to keep them in position and all such welding shall be deemed to be included in the unit rate quoted and no extra payment shall be made on this account.

38.3.6.8 Blockouts

Blockouts in concrete as indicated in the drawing or as directed by the Employer shall be provided wherever required. No extra payment shall be made to the Contractor on this account.

38.3.6.9 Repairs and Finishes of Concrete

All concrete surfaces shall have even and clean finish, free from honeycombs, air bubbles, fins or other blemishes. The formwork joints marks for concrete work exposed to view shall be rubbed with carborundum stone and defects patched up with a paste of 1 part sand and 1 part cement and cured. The finish shall be made to the satisfaction of the Employer. The unit rate of concrete work shall be inclusive of the cost of cleaning and finishing exposed surface as mentioned above.

38.3.7.0 Reinforcement Steel

This section of the specification shall cover providing reinforcement steel and its cleaning, bending, binding, placing with arrangements for chairs, supports and suitable covers for all reinforced concrete works, below and above ground level as per drawings and specifications.

38.3.7.1 **General Requirements**

38.3.7.1.1 Reinforcement steel of same type & grade shall be used for structural reinforcement work as detailed in the drawing released by the Employer. No work shall be commenced without proper verification with the bar-bending schedule provided in the drawing .

38.3.7.1.2 Contractor shall supply, fabricate and place reinforcement to shapes and dimensions as indicated on the drawings and as per specifications. The reinforcement shall be either plain or deformed steel bars or welded wire fabric conforming to relevant IS specifications.

38.3.7.1.3 Any adjustment in reinforcement to suit field conditions and construction joints other than shown on drawings shall be subjected to the approval of Employer.

38.3.7.2 Bending

38.3.7.2.1 Unless otherwise specified, reinforcement steel shall be bent in accordance with procedure specified in IS:2502. Bends and shapes shall comply strictly with the dimensions in the approved Bar Bending Schedule. Contractor shall be entirely responsible for its correctness. Bars correctly bend shall only be used.

38.3.7.2.2 No reinforcement shall be bent when in position in the work without approval of the Employer, whether or not it is partially embedded in concrete. Bars shall not be straightened in a manner that will injure the material. Rebending can be done only if approved by the Employer. Reinforcement bars shall be bent by machine or other approved means producing a gradual and even motion. All the bars shall be cold bent unless otherwise approved.

38.3.7.3 Placing in position

38.3.7.3.1 All reinforcement shall be accurately fixed and maintained in position as shown on the drawings by approved means as mild steel chairs, and/or concrete spacer blocks. Bars intended to be in contact, at crossing points, shall be securely bond together at all such points by two number No.20G annealed soft-iron wire. Binders shall tightly embrace the bars with which they are intended to be in contact and shall be securely held. The vertical distance between successive layers of bars shall be maintained by provision of mild steel spacer bars. They should be so spaced that the main bars do not sag preceptibly between adjacent spacers.

38.3.7.3.2 The placing of reinforcements shall be completed well in advance of concrete pouring. Immediately before pouring, the reinforcement shall be checked by the Employer for accuracy of placement and cleanliness and necessary correction as directed by him shall be carried out. The cover for concrete over the reinforcements shall be as shown on the approved drawings unless otherwise directed by the Employer. Care should be taken to ensure that projecting ends of ties and other embedded metal do not encroach into the concrete cover. Where concrete blocks are used for ensuring the cover and positioning reinforcement, they shall be made of mortar 1:2 (one part cement: two parts sand) by volume and cured for at least (7) days. The sizes and locations of the concrete blocks shall be approved by the Employer.

38.3.7.3.3 The longitudinal reinforcement shall project 52 times its diameter above cut-off level unless otherwise indicated in the drawing.

38.3.7.3.4 The minimum diameter of the links or spirals bar shall be 10mm and the spacing of the links or spiral shall not be less than 150mm and in no case more than 250mm. The laterals shall be tied to the longitudinal reinforcement to maintain its shape and spacing.

38.3.7.3.5 Reinforcement cage shall be sufficiently rigid to withstand handling and installation without any deformation and damage. As far as possible number of joints (laps) in longitudinal reinforcement shall be minimum. In case the reinforcement cage is made up of more than one segment, these shall preferably be assembled before lowering into casing tube/pile bore by providing necessary laps as per IS:456.

38.3.7.3.6 The minimum clear distance between the two adjacent main reinforcement bars shall normally be 100mm for the full depth of cage, unless otherwise specified.

38.3.7.3.7 The laps in the reinforcement shall be such that the full strength of the bar is effective across the joint and the reinforcement cage is of sound construction. Laps and anchorage lengths of reinforcing bars shall be in accordance with IS:456, unless otherwise specified. If the bars in a lap are not of the same diameter, the smaller will guide the lap length.

38.3.7.3.8 Laps shall be staggered as far as practicable and as directed by the Employer. Not more than 50% bars shall be lapped at a particular section. Lap joints shall be staggered by at least 1.3 times the lapped length (Center to Center).

38.3.7.3.9 Proper cover and central placement of the reinforcement cage in the pile bore shall be ensured by use of suitable concrete spacers or rollers, as required, without any additional cost to the Employer.

38.3.7.3.10 Minimum clear cover to the reinforcement shall be 75mm unless otherwise mentioned.

38.3.7.3.11 Unless otherwise specified by the Employer reinforcement shall be placed within the following tolerance as specified in IS:456:2000.

a) For effective depth 200mm or less +10mm.

b) For effective depth more than 200mm +15mm.

The cover shall in no case be reduced by more than one-third of specified cover or 5mm whichever is less.

38.3.7.3.12 Welding of reinforcement bars shall be avoided. However, welding may be done in specific case subject to prior permission from the Employer.

38.3.8.0 Construction of Pile Cap, Pedestal, Tie Beam etc.

The Contractor shall deploy all labour, equipment, tools & tackles and materials required for complete execution of the work in accordance with the drawings and as described herein.

38.3.8.1 Excavation

38.3.8.1.1 The Contractor shall control the grading in the vicinity of all excavation so that the surface of the ground will be properly slopped or diked to prevent surface water from running into the excavated areas during construction.

38.3.8.1.2 Excavation shall include the removal of all materials required to execute the work properly and shall be made with sufficient clearance to permit the placing, inspection and setting of forms and completion of all works for which the excavation was done.

38.3.8.1.3 Side and bottoms of excavation shall be cut sharp and true, undercutting shall not be permitted. Each side of excavation shall be used in lieu of formwork for placement of concrete unless authorised, in special cases, by the Employer, where limitation of space for larger excavation necessitate such decision.

38.3.8.1.4 When machines are used for excavation, the last 300mm before reaching the required level shall be excavated by hand or by such equipment that will leave the soil at the required final level, in its natural conditions.

38.3.8.1.5 Suitability for bearing of the bottoms of excavations shall be determined by the Employer.

38.3.8.1.6 The bottom of excavation shall be trimmed to the required level and when carried below such levels, by error, shall be brought to level by filling with lean concrete 1:4:8 mix, with aggregate of 40mm maximum nominal size at no additional cost to the Employer.

38.3.8.1.7 The Contractor shall be responsible for assumptions and conclusions regarding the nature of materials to be excavated and the difficulty of making and maintaining the required excavations and performing the work required as shown on the drawing and in accordance with these specifications. The Contractor shall be responsible for any damage to any part of the work and property caused by collapse of sides of excavations. Materials may be salvaged, if it can be done with safety for the work and structure, as approved by the Employer. However, no extra claim shall be entertained for materials not salvaged or any other damage to Contractor's property as a result of the collapse. He shall not be entitled to any claim for redoing the excavation as a result of the same.

38.3.8.1.8 Excavations for foundations specified shall be carried out at least 75mm or as specified in relevant drawings below the bottom of structural concrete and then be brought to the required level by placing lean concrete of 1:4:8 mix or as specified in drawings with aggregate of 40mm maximum nominal size.

38.3.8.1.9 When excavation requires coffer dams, sheet piling, bracing, sheeting, shoring, draining, dewatering etc. the Contractor shall have to provide the same as required and the cost there of shall be included in the unit rate quoted for the item of excavation and contractor shall submit necessary drawings showing arrangement and details of proposed installation and shall not proceed until he has received approval from the Employer.

38.3.8.1.10 The Contractor shall have to constantly pump out the water collected in pits due to rain water, springs, seepage etc. and maintain dry working conditions at no extra cost to the Employer.

38.3.8.1.11 For the purpose of excavation in earthwork, all types of soil including kankar, morum, shingle and boulders are included and no separate payment shall be made for different type of soils encountered.

38.3.8.4 Form work

38.3.8.4.1 General

38.3.8.4.1.1 If it is so desired by the Employer, the Contractor shall prepare, before commencement of the actual work, design and drawings for form work and centering and get them approved by the Employer. The form work shall conform to the shape, alignment and dimensions as shown in the drawings. Form work shall be composed of steel and/or best quality shuttering wood of non- absorbent type or plywood. Timber shall be free from significant knots and shall be of medium grain as far as possible and hard woods shall be used as caps and wedges under or over posts. Plywood or equivalent shall be used where specified to obtain smooth surfaces for exposed concrete work. Struts shall generally be mild steel tubes, and strong sal ballis of 150mm in diameter or above. Bamboos, small diameter ballis, etc. shall not be used unless approved by the Employer in specified cases.

Supports or props should not be supported on an unpropped lower suspended floor or beam unless calculations are submitted to the Employer to confirm the strength of the lower floor or beam and no propping shall be taken out until the Employer approval has been given.

38.3.8.4.1.2 The form work shall be true and rigid and thoroughly braced both horizontally and diagonally. The forms shall be sufficiently strong to carry without undue deformation, the dead weight of the concrete as well as working load. Where the concrete is vibrated, the formwork shall be strong enough to withstand the effects of vibration, without appreciable deflection, bulging, distortion or loosening off its components. The joints in the formwork shall be sufficiently tight to prevent any leakage of mortar. The formwork shall be such as to ensure a smooth uniform surface free from honeycombs, air bubbles, bulges, fins and other blemishes. Any blemish or defect found on the surface of the concrete must be brought to the notice of Employer immediately and rectified free of charge as directed by him. To achieve the desired rigidity, the bolts, space blocks, the wires and clamps as approved by the Employer shall be used but they must in no way impair the strength of concrete or leave stains or marks on the finished surface, where there are chances of these fixtures being embedded, only mild steel or concrete of adequate strength shall be used. Bolts passing completely through liquid retaining walls/slabs for the purpose of securing and aligning the formwork should not be used.

38.3.8.4.1.3 Temporary openings for cleaning, inspection and for pouring concrete may be provided at the base of vertical forms and as may be directed by the Employer. The temporary openings shall be so formed that they can be conveniently closed when required and must not leave any mark on the concrete.

38.3.8.4.2 Cleaning and Treatment of Forms

38.3.8.4.2.1 All forms shall be thoroughly cleaned of old concrete wood shavings, saw dust, dirt and dust sticking to them before they are fixed in position. All rubbish loose concrete, chippings, shavings, saw dust etc. shall be scrupulously removed from the interior of the forms before the concrete is poured. Along with wire brushes, brooms, etc. compressed air jet and/or water jet shall be kept handy for cleaning, if directed by the Employer.

38.3.8.4.2.2 Before shuttering is placed in position the form surface in contact with concrete shall be treated with approved non-standing oil or composition of other material approved by the Employer. Care shall be taken that the oil or composition does not come in contact with reinforcing steel or existing concrete surface. They shall not be allowed to accumulate at the bottom of the shuttering.

38.3.8.4.2.3 If formwork for pedestal/chimney is erected for the full height of the section, as placing of concrete proceeds, wedges, spacer bolts, clamps or other suitable means shall be provided to allow accurate adjustment of the formwork and to allow it to be removed gradually without jarring the concrete.

38.3.8.4.3 Removal of Forms

38.3.8.4.3.1 The Contractor shall begin the removal of formwork only after approval of Employer. He shall place on record the date on which the concrete is placed in different parts of the work and the date of the removal of formwork there from. This record shall be checked and countersigned by the Employer. The Contractor shall be responsible for the safe removal of formwork but the Employer may delay the time of removal if he considers it necessary. Any work showing signs of damage through premature removal of formwork or loading shall be entirely reconstructed without any extra cost to Employer.

38.3.8.4.3.2 Forms for various types of structural components shall not be removed before the minimum periods specified below which shall also be subject to the approval of the Employer.

38.3.8.4.3.3 No supporting forms shall be removed suddenly in such manner as to create shock loading. Forms for sides shall not be removed before 2 days. Bottom forms shall not be removed before 28 days unless this period is reduced with specified concurrence of the Employer. However, in any case, formwork shall not be struck until the concrete has reached a strength at least twice the stress to which the concrete may be subjected to, at the time of removal of forms.

38.3.8.4.4 Re-use of Forms

Before re-use, all forms shall be thoroughly scrapped cleaned and joints, etc. shall be examined, when necessary repaired and inside surface treated as specified. Formwork shall not be used/re-used, if declared unfit or unserviceable by the Employer.

38.3.8.5 Back Filling

38.3.8.5.1 General Requirement

38.3.8.5.1.1 After completion of foundation footings, pile caps, pedestals, tie beams and other constructions below the elevation of the grades, and prior to back filling, all forms of temporary shoring, timber etc. shall be removed and the excavation cleaned of all trash, debris and perishable materials, back filling shall begin only with the approval of the Employer.

38.3.8.5.1.2 The soil to be used for back filling purpose shall be inorganic material and shall be free from any foreign substance which can harm or impair the strength of footing in any manner. In any case the soil to be used for back filling purpose shall have the prior approval of the Employer.

38.3.8.5.1.3 The soil to be used for back filling purpose shall be either from the excavated earth or from the borrow pits, as directed by the Employer. The soil may have to be brought from a distance up to 2 km. By the shortest haulage route as approved by the Employer. If directed by the Employer, the excavated earth from the adjoining areas (which is to be disposed off up to a distance of 500 meters by manual labour) shall be used as for back filling purpose.

38.3.8.5.1.4 Back filling shall not be dropped directly upon or against any structure where there is danger of displacement or damage.

38.3.8.5.1.5 Back filling shall be placed in horizontal layers not to exceed 200mm in thickness. Each layer shall be compacted with proper moisture content and with such equipment as may be required to obtain a density equal to or greater than 95% of maximum dry density as determined by the relevant Indian Standard. The method of compaction shall be subject to the approval of the Employer. Pushing of earth for back filling shall not be adopted under any circumstances.

38.3.8.5.1.6 On completion of structures, the earth surrounding them shall be accurately finished to line and grade as shown on the drawings or as per the instruction of the Employer. Finished surface shall be free of irregularities and depressions and shall be within 50mm of the specified level.

38.3.8.5.1.7 Any additional quantity of back filling, if required, beyond the excavation payment line shall be done by the contractor at his own expense.

38.3.8.6 Construction Joints

a) When the work is to be interrupted, the concrete shall be rebated at the joint to such shape and size as may be required by the Employer or as shown on the drawings. All vertical construction joints shall be made with stone boards, which are rigidly fixed and slotted to allow for the passage of the reinforcing steel. If desired by the Employer, keys and/or dowel bars shall be provided at the construction joints.

Construction joints shall be provided in positions as shown or described on the drawing. Where it is not described, the joints shall be in accordance with the following :

i) In a column, the joint shall be formed about 75mm below the lowest soffit of the beams framing into it.

ii) Concrete in tie beam shall be placed throughout without a joint, but if the provision or a joint is unavoidable, the joint shall be vertical and at the middle of the span.

iii) In forming a joint, concrete shall not be allowed to slope away to thin edge. The locations of construction joints shall be planned by the Contractor well in advance of pouring and have to be approved by the Employer.

b) Before the fresh concrete is placed, the cement skin of the partially hardened concrete shall be thoroughly removed and surface made rough by hacking, sand blasting, water jetting, air jetting or any

other method as directed by the Employer. The rough surface shall be thoroughly wetted for about two hours and shall be dried and coated with 1:1 freshly mixed cement sand slurry immediately before placing the new concrete. The new concrete shall be worked against the prepared surface before the slurry sets. Special care shall be taken to see that the first layer of concrete placed after a construction joint is thoroughly rammed against the existing layer. Old joints during pour shall be treated with 1:1 freshly made cement sand slurry only after removing all loose materials.

c) The unit rate of concrete work shall include the cost of construction joints.

38.3.8.7 Curing and Protection of Concrete

Newly placed concrete shall be protected by approved means from rain, sun & wind. Concrete placed below ground level shall be protected from falling earth during and after placing. Concrete placed in ground

containing deleterious substances shall be kept free from contact with such ground or with water leaking from such ground during placing of concrete and for a period of three days or as otherwise instructed by the Employer after placing of concrete. The ground water around newly poured concrete shall be kept to an approved level by pumping or other approved means of drainage. Adequate steps shall be taken to prevent floatation or flooding. Steps, as approved by the Employer, shall also be taken to protect immature concrete from damage by debris, excessive loading, vibration etc. which may impair the strength or durability of the concrete. All fresh concrete shall be covered with a layer of Hessian or similar absorbent material and kept constantly wet for a period of seven days or more from the date of placing of concrete as per directions of the Employer. Curing can also be made by ponding. Concrete shall be cured by flooding with water of minimum 25mm depth for the period mentioned above. Step shall also be taken to protect immature concrete from damage debris by excessive loading, vibrations, abrasions, deleterious ground water, mixing

with earth or foreign materials, floatation etc. that may impair the strength and durability of the concrete. Approved curing compound can be used with the permission of the Employer. Such compound shall be applied to all exposed surfaces of the concrete as soon as possible after the concrete has set.

38.3.9.0 Pile Installation

Installation of piles shall be carried out as per pile layout drawings, installation criteria, technical specifications and the directions of the Employer.

38.3.9.1 Equipment and Accessories

38.3.9.1.1 The equipment and accessories for installation of bored cast-in-situ piles shall be selected giving due consideration to the sub soil conditions, ground water conditions and the method of casting, etc. These shall be of standard type and shall have the approval of the Employer.

38.3.9.1.2 The capacity of the rig shall be adequate so as to reach the specified founding level.

38.3.9.1.3 Provision shall be kept for chiseling within the pile bore, as specified in this specification. Chiseling shall be carried out only with the approval of Employer. The contractor must have the provision of equipment/accessories which can bore in the hard rock strata if required, without any additional cost implication to the Employer.

38.3.9.2 Installation Criteria

38.3.9.2.1 The Contractor while boring the pile bores, shall constantly collect the bore spoils and these shall be compared with the layer wise soil classifications reported in the bore-log details of the location, reported in

the soil investigation report. Should there be any variation between the two-soil classification, these shall be immediately reported to the Employer.

38.3.9.2.2 Whenever the rock strata is encountered in the pile bore, the Contractor shall immediately report the matter to the Employer and shall take up the work of rock chiseling or any other suitable method only after the certification/approval of the Employer. Since the piles are required to be terminated in the firm/hard strata and as stipulated in the construction drawing the Contractor shall demonstrate such founding strata and seek approval of the Employer before terminating the piles.

38.3.9.2.3 The pile should be socketed and founded in good rock only. Whenever rock strata is encountered at any pile bore and the level of good rock (i.e. rock strata is not highly fractured and weathered and core recovery is not less than 80% with RQD 70%) is different than that is given in the Geotechnical Investigation report, in that case to establish the level of good rock, core drilling is necessary to be carried out at least upto 5m depth in rock strata encountered by the contractor without any additional cost implication to AEGCL and no time extension will be permitted on this account.

38.3.9.2.4 In order to verify the terminating depth, where rock strata is met with, the rock samples obtained from the bore spoils of pile shall also be tested for point load strength index and these shall then be compared/correlated to the values of uniaxial compression strength test shown in the soil investigation report. Accordingly, the termination of piles in the socketing zone shall be done with prior approval of the Employer.

38.3.9.3 Control of position and alignment

Piles shall be installed vertically as accurately as possible as per the construction drawing. The permissible limits for deviation with respect to position and inclination/alignment shall conform to IS-2911 (Part I/Sec.2), as reproduced below.

38.3.9.3.1 Maximum permissible deviation in alignment is 1.5% . Piles should not deviate more than 75mm or D/10 whichever is less from their positions at the working level. In case of piles deviating beyond these limits, the piles should be replaced or supplemented by one or more additional piles including the revised cap size(as the situation may be) at no additional cost to the Employer. Any extra claim whatsoever from the contractor on this account shall not be entertained.

38.3.9.4 Boring

38.3.9.4.1 Boring operations shall be done by rotary or percussion type drilling rigs using Direct Mud Circulation (DMC), Reverse Mud Circulation (RMC) methods or grab method. In soft clays and loose sands bailer method, if used, shall be used with caution to avoid the effect of suction. In cohesive soils, use of water for boring shall be restricted to a minimum, while boring in cohesion less deposits water level in the bore hole shall be maintained at or slightly above the standing water table. Boring operations by any of the above methods shall be done using drilling mud. The bidder shall be required to furnish along with their bid, complete details regarding the installation of piles and the method by which they wish to install the piles.

38.3.9.4.2 The Contractor shall satisfy himself about the suitability of the method to be adopted for site. If DMC or RMC is used, bentonite slurry shall be pumped through drill rods by means of high-pressure pumps. The cutting tools shall have suitable pores for the bentonite slurry to flow out at high pressure. If the Contractor fails to make proper bore for any reason, the Contractor has to modify the boring technique and switchover to other boring methods as approved by the Employer at no extra cost to the Employer.

38.3.9.4.3 Working level shall be above the pile cut off level. After the initial boring of about 1.0 to 2.0m temporary guide casing shall be lowered in the pile bore. The diameter of guide casing shall be of such diameter to give the necessary finished diameter of the concrete pile. The center line of guide casing shall be checked before continuing further boring. Guide casing shall be minimum 2.0m length. Additional length of guide casing shall be used depending on the conditions of the strata, ground water level etc. as required by the Employer without any additional cost to the Employer.

38.3.9.4.4 Use of drilling mud (bentonite slurry) for stabilising the sides of the pile bore is necessary wherever subsoil is likely to collapse in the pile bore. Drilling mud to be used shall meet the requirement as given in IS/IEC.

38.3.9.4.5 The bentonite slurry and the cuttings, which are carried to the surface by the rising flow of the slurry shall pass through settling tanks of adequate size to remove the sand and spoils from the slurry before the slurry is recirculated back to the boring. The bentonite slurry mixing and recirculation plant shall be suitably designed and installed.

38.3.9.4.6 The bentonite slurry shall be maintained at 1.5m above the ground water level during boring operations and till the pile is concreted. When DMC or RMC method is used the bentonite slurry shall be under constant circulation till start of concreting.

38.3.9.4.7 The size of cutting tools shall not be less than the diameter of the pile as specified in the drawing and not more than 75mm.

38.3.9.5 Chiseling

38.3.9.5.1 Chiseling, if required, may be resorted to with the permission of the Employer below the socketing horizon. The chiseling tool or bit shall be of adequate size and weight so as to reach the desired depth.

38.3.9.6 Cleaning of Pile bore

38.3.9.6.1 After completion the pile bore up to the required depth, the bottom of the pile bore shall be thoroughly cleaned. Cleaning shall ensure that the pile bore is completely free from sludge/bored material, debris of rock/boulder etc. Necessary checks shall be made as given in this Section to confirm the thorough cleaning of the pile bore.

38.3.9.6.2 Pile bore shall be cleaned by fresh drilling mud through tremie pipe before start of concreting and after placing reinforcement.

38.3.9.6.3 Pile bore spoil along with used drilling mud shall be disposed off from site up to 2 Km. or as directed by the Employer.

38.3.9.7 Adjacent Structures

38.3.9.7.1 When working near existing structures care shall be taken to avoid any damage to such structures.

38.3.9.8 Concreting

38.3.9.8.1 Concreting shall not be done until the Employer is satisfied that the bearing strata (soil/rock) met with the termination level of pile, satisfied the installation criteria/approved founding depth.

38.3.9.8.2 The time between the completion of boring and placing of concrete shall not exceed 6 hrs. In case the time interval exceeds 6 hrs the pile bore shall be abandoned. However, the Employer may allow concreting, provided the Contractor extends the pile bore by 0.5 m beyond the proposed depth, and clean the pile bore properly. The entire cost of all operation and materials for this extra length shall be borne by the Contractor.

38.3.9.8.3 Pile bore bottom shall be thoroughly cleaned to make it free from sludge or any foreign matter before and after placing the reinforcement cage.

38.3.9.8.4 Proper placement of the reinforcement cage to its full length shall be ensured before concerting.

38.3.9.8.5 Entire concreting in pile bores shall be done by tremie method. The operation of tremie concreting shall be governed by IS:2911 Part I/Sec.2.Drilling mud shall be maintained sufficiently above the ground water level.

38.3.9.8.6 Concreting operations shall not proceed if the contaminated drilling mud at the bottom of the pile bore possess density more than 1.25 T/Cu.m. or sand content more than 7%. The drilling mud sample shall be collected from the bottom of pile bore. This shall be checked at regular intervals, as decided by the Employer thereafter.

38.3.9.8.7 Consistency of the drilling mud suspension shall be controlled throughout concreting operations in order to keep the bore stabilised as well as to prevent concrete getting mixed up with the thicker suspension of the mud.

38.3.9.8.8 It shall be ensured that volume of concrete poured is at least equal to the theoretically computed volume of pile shaft being cast.

38.3.9.8.9 The temporary guide casing shall be entirely withdrawn cautiously, after concreting is done up to the required level. While withdrawing the casing concrete shall not be disturbed.

38.3.9.8.10 Tests on concrete cubes shall be carried out as specified in this section of the Specifications.

38.3.9.9 Cut-off-level (COL)

38.3.9.9.1 Cut-off-level of piles shall be as indicated in approved construction drawings or as directed by the Engineer-in-Charge.

38.3.9.9.2 The top of concrete in pile shall be brought above the COL to remove all laitance and weak concrete and to ensure good concrete at COL for proper embedment into pile cap.

38.3.9.9.3 When the pile cut off level is less than 1.0 meter below the working level, concrete shall be cast up to the piling platform level to permit overflow of concrete for visual inspection. In case COL of pile is more than 1.0 meter below working level then concrete shall be cast to minimum of one meter above COL.

38.3.9.9.4 In the circumstances where COL is below ground water level, the need to maintain a pressure on the unset concrete equal to or greater than water pressure shall be observed and accordingly length of extra concrete above COL shall be determined by the Contractor with prior approval of Employer.

38.3.9.10 Sequence of Piling

38.3.9.10.1 Each pile shall be identified with a reference number and date wise proper record of construction shall be maintained by the Contractor.

38.3.9.10.2 The convenience of installation may be taken into account while scheduling the sequence of piling in a group. This scheduling shall avoid piles being bored close to other recently constructed piles.

38.3.9.11 Building up of Piles

38.3.9.11.1 If any pile, already cast as per construction drawing, requires any extra casting due to any change in cut off level or the cast pile top level is less than the specified level or for any other reason, then the pile shall be built up by using M-20 grade of concrete with minimum cement content 400kg/m3, ensuring proper continuity with the existing concrete and to the satisfaction of the Employer. Necessary reinforcement as per design requirement and suitable shuttering shall be provided before casting the concrete. Surrounding soil shall also be built up to the required level by proper compaction to ensure lateral capacity of the pile.

38.3.9.12 Breaking off of Piles

38.3.9.12.1 If any pile already cast requires breaking due to lowering in cut off level or for any other reason, then the same shall be carried out, (not before seven days of casting of concrete in the piles) without affecting the quality of existing pile such as loosening, cracking etc. to the satisfaction of the Employer. No extra payment shall be made on this account.

38.3.9.13 Preparation of Pile head

38.3.9.13.1 The soil surrounding the piles shall be excavated up to the bottom of the lean concrete below the pile cap with provision for working space sufficient enough to place shuttering, reinforcement, concreting and any other related operations.

38.3.9.13.2 The exposed part of concrete above the COL, shall be removed/chipped off and made square at COL not before seven days of casting of pile.

38.3.9.13.3 The projected reinforcement above COL shall be properly cleaned and bent to the required shape and level to be anchored into the pile cap as shown in the drawing.

38.3.9.13.4 The pile top shall be embedded into the pile cap by minimum 50mm or clear cover to reinforcement, whichever is higher.

38.3.9.13.5 All loose material on the top of pile head after chipping to the desired level shall be removed and disposed off up to a lead of 2km or as directed by the Employer.

38.3.9.14 Rejection and Replacement of Defective Piles

38.3.9.14.1 The Employer reserve the right to reject any pile which in his opinion is defective with reference to technical specification & construction drawings on account of load capacity, structural integrity, position, alignment, concrete quality etc. Piles that are judged defective shall be pulled out or left in place as decided by the Employer without affecting the performance of adjacent piles. The Contractor shall install additional piles to substitute the defective piles as per the directions of the Employer at no extra cost to the Employer.

38.3.9.14.2 During execution of pile foundation work, if the bore holes need to be abandoned due to any reason and pile position to be shifted or realigned, other than for any design requirement by the Employer, fresh bore holes are to be executed at a suitable new position, which may vary from 2D to 3D (where, D is diameter of pile) as decided by the Employer, which may demand for resizing of pile cap including possible increase in reinforcement quantity due to resizing of pile cap. In all such cases the abandoned bore holes are to be filled up with plain cement concrete M15 so that no cavity remains in the bore hole of the abandoned pile.

Any extra claim whatsoever from the contractor on account of abandoned bore hole, filling up of abandoned bore hole with concrete and any extra cost due to resizing of pile cap including increase in reinforcement quantity shall not be entertained by the Employer & the same have to be borne by the contractor.

38.3.9.15 CRITERIA FOR TERMINATING THE PILES

38.3.9.15.1 The piles can be terminated at a depth based on design developed by the Employer, where loads on the piles can be transmitted to the soil in a proper manner or the depth where specified `N' value is achieved, whichever occurs later. However, in no case piles should be terminated at a higher level than that indicated in the construction drawing.

38.3.9.15.2 Standard penetration test (SPT) shall be carried out starting from 1.0 M above the specified pile termination depth and there after @ 1m. up to the pile termination depth.

38.3.9.15.3 The Standard Penetration Test (SPT) shall be carried out based on the following test procedures:

The test shall be conducted by driving a standard split spoon sampler in the borehole by means of a 650 N hammer having a free fall of 0.75 M. The sampler shall be driven for 450 mm using the hammer and the number of blows shall be recorded for every 150mm penetration. The number of blows for the last 300 mm drive shall be reported as N value. The test shall be discontinued when the blow count is equal to 100 or the penetration is less than 25mm for 50 blows, whichever is earlier. At the location where the test discontinued, the penetration and the number of blows shall be reported. Sufficient quantity of disturbed sample shall be collected from the split spoon sampler for identification/classification of soil. The sample shall be visually classified and recorded at the site. The specification for the equipments and other accessories, procedure for conducting the test and collection of the disturbed soil sample shall conform to IS:2131.

38.3.9.16 Recording of Piling Data

38.3.9.16.1 The Contractor shall record all the information during installation of piles.

Typical data sheet for recording pile data as shown in Appendix D of IS:2911 Part I/Sec.2 shall be maintained by the contractor. The pile data shall also include all the details. On completion of each pile installation, pile record in triplicate shall be submitted to Employer within two days of completion of concreting of the pile.

38.3.9.17 Check for Pile bore

38.3.9.17.1 On completion of boring and cleaning the bottom of each pile bore shall be checked by the methods as approved by the Employer, to ensure that it is free from pile bore spoil/debris and any other loose material, before concreting. Concreting shall be done only after the approval of the Employer.

38.3.9.17.2 For sampling of drilling mud from the pile bore the following method or any other suitable method shall be adopted. A solid cone shall be lowered by a string to the bottom of pile bore. A sampler tube closed at top with a central hole (hollow cylinder) is lowered over the cone, then a top cover shall be lowered over the cylinder. Care shall be taken for proper fittings of assembly to minimise the leakage while lifting the cone assembly to the ground surface. The slurry collected in the sampler tube shall be tested for density and sand content.

38.3.9.18 Properties of drilling mud

38.3.9.18.1 Properties of drilling mud shall be checked as per requirements indicated in IS/IEC prior to the commencement of piling work and thereafter at least once in a week or as found necessary by the Employer, one sample consisting of 3 specimens shall be tested.

38.3.9.18.2 Density and sand content of the drilling mud shall be checked in each pile.

38.3.10.0 Erection of Steel Embedded Parts

38.3.10.1 This covers the technical requirements for the supply and fabrication and/or erection of all embedded steel parts by the Contractor. The extent and type of embedded steel parts to be erected shall be as per detailed drawings.

38.3.10.2 The supply of embedded steel parts like ladders, steel pieces set in concrete inserts, dowel bars required for construction joints etc. are in the scope of the Contractor. However, supply of anchor bolts/stubs, as the case may be, will be supplied by tower contractor.

38.3.10.3 Embedded steel parts shall include items such as foundation anchor bolts, stubs, ladders, steel pieces set in concrete inserts, dowel bars for concrete work etc. shown on the drawing or as required by the Employer.

Material shall also include setting in forms for connecting in place and grouting as required. The grouting operations, if required, shall be performed as per the direction of Employer.

38.3.10.4 The Contractor shall erect all embedded steel parts in accordance with the drawings and these specifications including setting materials in concrete or grouting pieces in place, furnishing all labour, materials, scaffolding, tools and services necessary for and incidental to the work to its transporting, unloading, storing, handling and erection. Contractor shall furnish welding rods and arrange for field welding as required in accordance with IS : 816.

38.3.10.5 Exposed surface of embedded material are to be painted with one coat of approved anticorrosive and/or bituminous paint without any extra cost to the Employer. The threads of holding down bolts shall be greased and protected with water proof tape.

38.3.11.0 Installation

38.3.11.1 During erection, the Contractor shall provide necessary temporary bracing or supports to ensure proper installation of the materials. All materials shall be erected in the true locations as shown in the drawings, plumb and level. Extreme care shall be taken to ensure that the threads of holding down bolts and comparable items are protected from damage.

38.3.11.2 Groups of holding down bolts shall be set in such a manner that the tolerance of whole group is not more than 3mm from its true position in plan at the top of the bolt and not more than 3mm from the required level. The top ends of all bolt shanks shall be in one plane to the tolerance stated above. Holding down bolt assemblies shall be set vertically to a tolerance of not more than 1:500.

38.3.12.0 Protection Against Damage in Transit

38.3.12.1 All steel work shall be efficiently and sufficiently protected against damage in transit to site from any cause whatsoever. All protecting plates or bars and all ends of members at joints shall be stiffened, all straight bars and plates shall be bundled, all screwed ends and machined surface shall be suitably packed and all bolts, nuts, washers and small loose parts shall be packed separately in cases so as to prevent damage or distortion during transit. Should there be any distortion of fabricated members, the Contractor shall immediately report the matter to the Employer. Distorted reinforcement bars or plates received from stores or distorted during transport from stores to the fabrication yard shall not be used in fabrication unless the distortions are minor which in the opinion of the Employer can be removed by acceptable methods. The cost of all such straightening shall be borne by the Contractor within his unit rates. These distortions shall be rectified by the Contractor by cold bending. If heating is necessary to rectify the defects, the details of the procedure shall be intimated to the Employer whose approval shall be taken before such rectification. The temperature of heat treatment shall not exceed the limits beyond which the original properties of steel are likely to be impaired.

38.3.13.0 Foundations Bolts

38.3.13.1 The foundation bolts / stubs, as required, for the tower structures shall be supplied by the respective tower contractor. These shall be embedded in concrete while the foundation is cast. The Contractor shall ensure the proper alignment of these bolts to match the holes in the base plate and also co-ordinate with the respective tower contractor for its correctness. The final adjustment of these bolts and their grouting are included in the scope of this contract. Grouting of block outs and the gap between the base plate and top of concrete shall be done by the Contractor after finalisation of alignments. The unit rate of concreting shall include the cost of above adjustments, grouting, and skins etc. required for this purpose.

38.3.13.2 The Contractor shall be responsible for the correct alignment and levelling of all steel work on site to ensure that the towers are in plumb.

38.3.13.3 Before erection of towers, by tower contractor, on the foundations the top surface of base concrete shall be thoroughly cleaned with wire brushes and by chipping to remove all laitance and loose materials and shall be chipped with a chisel to ensure proper bond between the grout and the foundation concrete. The piling Contractor shall also be responsible for bringing down the top of concrete to the desired level by chipping. In case the foundation as cast is lower than the desired level, the Contractor shall make up the difference by providing additional pack plates without extra cost for any such work or material. No steel structures shall be erected on their foundations unless such foundations have been certified fit for erection by the Employer. Adequate number of air release holes and inspection holes shall be provided in the base plate.

38.3.14.0 Stability of Structure

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

38.3.14.2 Guying and bracing shall be done for erection equipment and their operations. Guying and bracing shall be done in such a way that it does not interface with the movement or working of other agencies working in the area. For the purpose of guying, the Contractor shall not use other structures in the vicinity which are likely to be damaged by the guy. Such temporary bracings shall neither be included in the measurement nor extra rate shall be payable. Such temporary bracings used shall be the property of the Contractor and may be removed by him at the end of the job from the site of work.

38.3.15.0 Grouting and under Pinning

38.3.15.1 General requirement

38.3.15.1.1 Furnishing of all labour materials and equipment and performance of all operations necessary to complete the work of grouting of block outs and foundation bolt holes and under pinning of base plates is in the scope of the Contractor. The cost of the above shall be included in the unit concreting rate.

38.3.15.1.2 Grouting shall be adopted for filling the block outs, pockets below foundation bolt holes. The block out and bolt holes which have to be grouted shall be cleaned thoroughly by use of compressed air immediately before taking up the grouting operations.

38.3.15.1.3 Cement and alluminium powder or anti-shrinkage admixture of approved quality shall be first blended thoroughly in the required proportions as per manufacturer’s specification. The mix of grouting shall contain one part of cement and two parts of coarse sand. Admixture should be according to IS:9103.

38.3.15.1.4 The quantity of aluminum powder shall usually be of the order of 0.005% by weight of cement. Any grout which has been mixed for a period longer than half an hour shall not be used on the work. Immediately after preparation the grout shall be poured into the block outs, pockets and foundation bolt holes either from the sides or through the holes provided for this purpose in the base plate, by using special equipment for pressure grouting. It shall be ensured by rodding and by tapping of bolts that the block out is completely filled without leaving any voids. The pouring shall cease as soon as each hole is filled and any excess grout found on the surface of the concrete foundation shall be completely removed and the surface dried.

38.3.15.1.5 Under pinning It shall be resorted to for filling the space between the underside of base plate and the top of foundation concrete. After grouting has been completed as specified above, space between the top surface of the foundation concrete and the underside of the base plate shall be filled with mortar or concrete depending upon thickness to be filled as follows :

Less than 40mm Dry packed cement mortar Over 40mm Dry packed fine concrete Mortar, fine concrete shall be blended with aluminium powder about 0.005% by weight of cement or with anti-shrinkage admixture in a suitable proportion to the cement mortar in accordance with the recommendations of the manufacturer and subject to the approval of the Employer. Mortar shall comprise cement, sand and water in proportion of approx. 1:3:0.4 by weight. Concrete shall comprise cement, sand, 10mm max. Sized aggregate and water in proportion of 1:1.25:2:0.4 by weight. In all cases minimum 28 days cube strength should not be less than 25N/mm2. Shims provided for the alignment of bases shall be positioned at the edges of the base to permit subsequent removal which shall take place not less than 7 days after the underpinning has been executed. The resulting cavities shall be made good with the same grade of mortar or concrete as has been used for the underpinning of the rest of the base plate.

38.3.15.1.6 Cement, sand and aluminium powder or approved anti-shrinkage admixture, shall first be blended thoroughly in the required proportion. The mortar shall then be prepared by mixing with quantity of water which will produce a sufficiently workable mix to enable complete and proper compaction of the mortar.

38.3.15.1.7 The mortar shall then be placed below the base plate and rammed in a horizontal direction for each edge until the mortar oozes out through the grout holes provided in the base plate.

38.3.15.1.8 When it is clear that the center of base has been properly filled, the mortar outside the base plate shall be briefly rammed to ensure compaction below the edges. Any mortar which has been mixed for a period longer than half an hour, shall not be used in the work.

38.3.15.2 Materials

38.3.15.2.1 Cement shall conform to the stipulations contained in IS:8112and shall have a fineness (specific surface of cement) not less than 225 sq.m./kg when tested for fineness by Blaine’s air permeability method as per IS:4031.

38.3.15.2.2 Sand shall conform to the stipulations contained in IS:383.

38.3.15.2.3 Water shall be clean and fresh and shall be of potable quality.

38.3.15.2.4 Aluminium powder or anti-shrinkage admixture like ‘Groutex’ CRS-NS grout (by Cement Research Institute of India) or its equivalent shall be of standard brand from reputed manufacturer and shall be approved by the Employer prior to its use for work.

38.3.15.3 CURING

The work shall be cured for a period of 7 days commencing 24 hours after the completion of the grouting and under pinning operations. The curing shall be done by covering the surfaces with wet gunny bags.

38.3.16.0 Bar Grips

38.3.16.1 This covers the technical requirement for furnishing and installation of bar grips complete including all labour materials, equipments, staging, etc.

38.3.16.2 The Contractor shall furnish and install the bar grips for various dia. of deformed bars as indicated in drawings and as required by these specifications. The bar grip splicing system shall be of approved manufacturer and of the best quality available subject to approval of the Employer.

38.3.17.0 Splicing

38.3.17.1 a) The reinforcement bars are to be joined without any gap and the sleeve placed in position.

> b) Pressure is applied by means of a hydraulic press which swages the sleeve down on the bar ends in a series of bites which are applied at high pressure.
>
> c) The job can also be done in two stages. The 1st stage is to press the half sleeve on the loose bar at the reinforcement yard. The 2nd stage work is to be done at the actual site after the loose bar is inserted through the unpresented end of the sleeve and pressed in-situ.

38.3.17.2 The joints shall be staggered as far as possible. Necessary staging arrangements are to be made by the Contractor.

38.3.17.3 It may be necessary to fix the sleeve to the reinforcement bars at one end in the open yard for the facility of working. All these working details are to be furnished earlier subject to the approval of the Employer.

38.3.17.4 The length of the sleeve should be adequate, that it is safe under the pull-out loading conditions.

38.3.17.5 One percent representative samples of each dia. bars shall be sent for laboratory testing at the cost of the Contractor to check the efficiency of the joints under ideal condition. These samples of sleeves will be sent in the Laboratory for pull out tests.

38.3.17.6 All bar grips installation shall be subject to inspection and approval by the Employer before concreting operation are performed. In case of any defect or joint being not up to mark, the same shall be replaced by the Contractor at no extra cost.

38.3.18.0 MS Liner

MS liner (minimum 10 mm thick) shall be provided in line with Geo-Technical investigation report relevant IS Codes wherever included in the construction drawings Approved by the Employer and/or otherwises required by the Employer.

NOTE:
At the time of execution, the soil strata should match with the parameters considered in the design of pile foundation. For that req. standard penetration tests will be carried out by contractor to ascertain the design parameters. Any change req. in design will have to be carried out with the prior approval of Engineer-in-charge.

CHAPTER 39: TOWER FOUNDATION FOR 400KV TRANSMISSION LINES

39.0.1 SCOPE: This section covers the specifications for design of foundations for various types of towers and special structures under different soil condition described herein after.

39.0.1 STANDARDS: For design of foundations reference shall be made to IS 4091 and relevant IS codes. Reference shall also be made to 'Transmission Line Manual' issued by Central Board of Irrigation and Power, New Delhi.

39.1 Foundations

Foundation includes supply of all labour, tools & machineries, materials such as cement, sand, coarse aggregates and reinforcement steel and all associated activities, such as, excavation, concreting etc.

39.2 Type of Foundations

The foundation shall be of open cast type. Plain Cement Concrete/Reinforced Cement Concrete footing shall be used for all type of normal towers. All the four footings of the tower and their extensions shall be similar for a particular location, except where soil condition and or water table are different at different legs. The total depth of foundation, below ground level shall be 3.0 to 3.5meters. For Hard Rock type and also where specific site conditions / properties demand foundation of different depths (lower or higher), the same shall be adopted.

39.3 Classifications of Foundations:

The foundation designs shall depend upon the type of soil, sub soil water level and the presence of surface water which have been classified as follows (except pile foundations which is described in Section V of this specification).

39.3.1 Normal dry

To be used for locations where normal dry cohesive or non-cohesive soils are met. Foundations in areas where surface water encountered from rain runoff or agricultural fields (except paddy fields) shall also be classified as normal dry.

39.3.2 Sandy Dry Soil

To be used for locations where cohesion less pure sand or sand with clay content less than 10% met in dry condition.

39.3.3 Wet

To be used for locations:

a) Where sub-soil water is met between 1.5 meters and the depth of foundation below the ground level.

b) Which are in surface water for long period with water penetration not exceeding one meter below the ground level e.g. paddy fields.

39.3.4 Partially Submerged

To be used at locations where sub-soil water table is met between 0.75 meter and 1.5 metre below the ground level.

39.3.5 Fully Submerged

To be used at locations where sub-soil water table is met at less than 0.75 meter below the ground level.

39.3.6 Black Cotton Soil

To be used at locations where soil is clayey type, not necessarily black in colour, which shrinks when dry and swells when wet, resulting in differential movement.For designing foundations, for such locations, the soil is considered submerged in nature.

39.3.7 Fissured – Rock

To be used at locations where decomposed or fissured rock, hard gravel, kankar, limestone, laterite or any other soil of similar nature is met. Under cut type foundation is to be used for fissured rock locations. In case of fissured rock locations, where water table is met at 1.5M or more below ground level, wet fissured rock foundations shall be adopted. Where fissured rock is encountered with subsoil water table less than 0.75 meter below ground level, submerged fissured rock foundations shall be adopted. In case of dry locations dry fissured rock foundations shall be adopted.

39.3.8 Hard Rock

The locations where chiseling, drilling and blasting is required for excavation, Hard rock type foundations are to be used. For these locations rock anchoring is to be provided to resist uplift forces.

39.3.9 Where soil is of composite in nature, classification of foundation shall be according to the type of soil predominant in the footing.

39.4 Design of Foundations

39.4.1 Design of foundations as classified under Cl. 39.2.3 for all towers and towers with extensions shall be developed the contractor, based on their soil investigation report and approved thereof by Employer.

39.4.2 Depending on the site conditions other types of foundations shall also be designed and provided by the Owner suitable for Intermediate conditions under the above classifications to effect more economy or to suit specific site conditions encountered.

39.4.3 The proposal for these types of foundations shall be submitted by the Contractor based on the detailed soil investigation and duly recommended by Engineer-incharge.

39.4.4 The special foundations like pile foundations if required shall also be designed by the Owner based on detailed soil investigation report .The working drawing of these foundations shall be provided by the Employer to the Contractor during execution stage based on requirements. For detailed specification for pile foundations Section VIII of this specification shall apply.

39.5 Soil Investigation

Soil investigations shall be carried out by the Contractor. Rate shall be included in the unit cost of foundation. No extra payment shall be made by Employer.

39.7 Construction of Tower Foundation, Stub Setting and Earthing

39.7.1 Excavation

39.7.1.1 The excavation work for foundations shall be taken up by the contractor progressively stretch wise / section wise after obtaining approval from Owner for the proposed stretch wise / section wise tower schedule, profile etc. as per detailed survey along the approved route alignment.

39.7.1.2 Except as specifically otherwise provided, all excavation for footings shall be made to the lines and grades of the foundations. The excavation wall shall be vertical and the pit dimensions shall be based on an assumed clearance of 150mm on all sides of the foundation pad. For footings with undercut, care shall be taken to carry out excavation as per drawing without any side clearance. All excavation shall be protected so as to maintain a clean sub grade and provide worker safety until the footing is placed, using timbering, shoring, shuttering, dewatering etc. as approved by the Owner. Contractor shall especially avoid disturbing the bearing surface of the pad. Any sand, mud, silt or other undesirable materials which may accumulate in the excavated pit or borehole shall be removed by Contractor before placing concrete.

39.7.1.3 The soil to be excavated for tower foundations shall be classified as follows depending upon the physical state of the soil at the time of excavation irrespective of the type of foundation installed.

a) Dry Soil
Soil removable either manually, by means of a spade and shovel or mechanically by proclaims, excavators etc. Excavation done in dry soil for wet, partially submerged, fully submerged and wet black cotton type of foundations shall also be covered under this.

b) Wet Soil
Where the subsoil water table is encountered within the range of foundation depth or land where pumping or bailing out of water is required due to presence of surface water shall be treated as wet soil. The excavation done in wet soil in case of wet, partially submerged, fully submerged and wet black cotton type of foundation shall also be covered under this .

c) Dry Fissured Rock
Limestone, laterite, hard conglomerate or other soft or fissured rock in dry condition which can be quarried or split with crowbars, wedges, pickaxes etc. However, if required, light blasting may be resorted to for loosening the material but this will not in any way entitle the material to be classified as hard rock.

d) Wet Fissured Rock
Above fissured rock, when encountered with subsoil water within the range of foundation depth or land where pumping or bailing out of water is required, shall be treated as wet fissured rock.

e) Hard Rock
Any rock excavation, other than specified under fissured rock above, for which blasting, drilling, chiseling are required. The unit rate quoted for hard rock excavation shall be inclusive of all costs for such drilling (including drilling required for anchoring), chiseling and blasting, etc.

39.7.1.4 No extra payment shall be admitted for the removal of fallen earth into a pit or borehole once excavated.

39.7.1.5 Where rock is encountered, the holes for tower footings shall preferably be drilled. Blasting where resorted to as an economy measure, shall be done with utmost care to minimise fracturing rock and using extra concrete for filling the blasted area. All necessary precautions for handling and use of blasting materials shall be taken. In cases where unnecessarily large quantities are excavated/blasted, resulting in placement of large volumes of concrete, payment of concrete shall be limited to design volumes of excavation, concreting, reinforcement etc. In case where drilling is done, the stubs may be shortened suitably with the approval of the Owner.

39.7.1.6 The Contractor shall arrange & supply requisite blasting material, and be responsible for its storage and use, without any extra cost to the Owner.

39.7.1.7 Indian Standard IS:3764 shall be followed regarding safety of excavation work.

39.8 Unit Rates and Measurement for Foundation

39.8.1 The indicative shape of RCC foundations are enclosed in this Specification. The bidder is required to quote the unit rates for different foundation activity as a whole for geo-technical investigation, excavation for different types of soils, shuttering & shoring, concreting, backfilling, supply and placement of reinforcement steel, dewatering and all other incidental items for completion of the work.

39.8.2 The unit rates of excavation for each type of soil shall include excavation along with all associated activities like shoring, shuttering, dewatering till completion of foundation work stock piling, dressing, back filling of foundations after concreting
with excavated/borrowed earth (irrespective of lead) and consolidation of earth, carriage of surplus earth to the suitable point of disposal as required by the Owner or any other activity required for to completion of foundation work in all respect. The measurement for excavation shall be made on the basis of design excavation Volume arrived at considering dimension of pit leaving 150mm gap around (except for under cut foundations) the base pad or actually excavated whichever is less and the unit rate of this item as indicated in Letter of Award. The payment for excavation shall be made as per actual type of soil encountered at the time of excavation, but the total payment for excavation portion shall not exceed the amount as payable for excavation considering the soil type same as that of foundation classification. The decision of the Owner shall be final and binding with respect to classification of soil and foundations.

39.8.3 Form boxes shall be used for casting of foundations. The unit rate of concreting
shall include the cost of supply, fabrication and placement of form boxes, cement, water, coarse and fine aggregates mixing and placing of concrete, curing of concrete and any other activities related / required for completion of concreting works of foundation. The payment for this item shall be made as per the actual volumes of concreting completed but limited to design volume based on unit rates indicated in the letter of award.

39.8.4 The unit rate of ‘Reinforcement Steel’ shall include supply and placement of reinforcement steel, stirrups, wire for binding the reinforcement, chairs, bolsters and spacers etc. as required to complete the foundation work. The measurement of reinforcement steel for payments shall be made based on the calculated weight of reinforcement steel in tones corrected to third place of decimal as per relevant Indian Standard and as per working drawing or the quantity of reinforcement steel actually used, whichever is less. No allowance permitted towards wastage.

39.9 **Setting of Stubs**

39.9.1 The stubs shall be set correctly and precisely in accordance with approved method at the exact location, alignment and levels with the help of stub setting templates and leveling instruments. Stubs setting shall be done in the presence of Owner’s representative available at site where required and for which adequate advance intimation shall be given to Owner by Contractor. Tolerances as per provisions of IS:5613 shall be allowed for stub setting.

39.9.2 Setting of stub at each location shall be approved by Owner.

39.9.3 However, in hilly region for towers with unequal leg extensions and for river crossing towers, props may be used with complete accuracy and high skilled supervision, subject to prior approval from Owner.

39.9.4 For all towers the Contractor shall submit for approval the proposed method for setting of stubs.

39.10.5 Stub Setting Templates / Props

39.10.5.1 Stub setting templates shall be arranged by the Contractor at his own cost for all heights of towers. Stub templates shall be of adjustable type. The Contractor shall also arrange for props for setting of stubs at specific locations where use of prop is approved by the Owner. Stub templates / props should be painted

39.10.5.2 The Contractor shall deploy sufficient number of templates / props for timely completion of the line without any extra cost to Owner.

39.10.5.3 However following minimum number of stub setting templates may be deployed by the Contractor for every 100km of line length subject to minimum of 5 templates for suspension tower

Templates for tower type	**Nos. to be deployed**
i) A/DA	10
ii) For each type of B/DB, C/DC and D/DD type	3
iii) For A/DA +18/25 M	1
iv) for D/DD+18/25 M	1

However, if more templates are required for timely completion of the lines, the Contractor shall deploy the same without any extra cost to Owner. The number of sets of prop (if permitted) to be supplied, will depend as per actual site condition and completion schedule of line.

39.10.5.4 One set of each type of stub setting template **/** props (if used) shall be supplied to the Owner, on completion of the project, at no extra cost to Owner.

39.10 Mixing, Placing and Compacting of Concrete

39.10.1 The concrete shall be mixed in the mechanical mixer. However, in case of difficult terrain, hand mixing may be permitted at the discretion of the Owner. The water for mixing concrete shall be fresh, clean and free from oil, acids and alkalis. Saltish or blackish water shall not be used.

39.10.2 Mixing shall be continued until there is uniform distribution of material and mix is uniform in colour and consistency, but in no case the mixing be carried out for less than two minutes. Normal mixing shall be done close to the foundation but exceptionally, in difficult terrain**,** the concrete may be mixed at the nearest convenient place. The concrete shall be transported from the place of mixing to the place of final deposit as rapidly as practicable by methods which shall prevent the segregation or loss of any ingredient. The concrete shall be placed and compacted before setting commences.

39.10.3 To avoid the possibility of reinforcement rods being exposed due to unevenness of the bottom of the excavated pit, a pad of lean concrete 50mm thick and corresponding to a 1:3:6 nominal mix shall be provided at the bottom of the pad.

39.10.4 Form boxes shall be used for casting all types of foundations except at an undercut interface for which the adjoining subsurface material shall provide adequate support.

39.10.5 The concrete shall be laid down in 150mm layers and consolidated well, so that the cement cream works, up to the top and no honey-combing occurs in the concrete. A mechanical vibrator shall be employed for compacting the concrete. However, in case of difficult, terrain, manual compaction may permit at the discretion of the Owner. Monolithic casting of foundations must be carried out. However, in case of unavoidable circumstances, a key construction joint can be provided at the chimney-pad interface subject to approval of the Owner.

However, nothing extra shall be paid to the Contractor for providing such construction joints. After concreting the chimney portion to the required height, the top surface should be finished smooth with a slight slope towards the outer edge for draining rain water.

39.10.6 Wet locations shall be kept completely dewatered, both during and 24 hours after placing the concrete, without disturbance of the concrete.

39.10. 7 If minor defects in concrete surface is found after the form work has been removed, the damage shall be repaired with a rich cement sand mortar to the satisfaction of the Owner before the foundation is back filled.

39.11 Curing

The concrete shall be cured by maintaining the concrete wet for a period of at least 10 days after placing. Once the concrete has set for 24 hours the pit may be backfilled with selected moistened soil and well consolidated in layers not exceeding 200mm thickness and thereafter both the backfill earth and exposed chimney shall be kept wet for the remainder of the prescribed 10 days. The exposed concrete chimney shall also be kept wet by wrapping gunny bags around it and wetting the bags continuously during the critical 10 days period.

39.12 Backfilling and Removal of Stub Templates

39.12.1 After opening of formwork and removal of shoring, timbering, etc., backfilling shall be started after repairs, if any, to the foundation concrete. Backfilling shall normally be done with the excavated soil, unless it is a clay type or it consists of large boulders/stones, in which case the boulders shall be broken to a maximum size of 80-mm. At locations where borrowed earth is required for backfilling, Contractor shall bear the cost irrespective of leads & lift.

39.12.2 The backfilling materials shall be clean and free from organic or other foreign materials. A clay type soil with a grain size distribution of 50% or more passing the no**.** 200 sieve are unacceptable for backfilling. The earth shall be deposited in maximum 200mm layers, levelled, wetted if necessary and compacted properly before another layer is deposited. The moisture content for compaction shall be based on the Proctor compaction test results given in the Geo-technical Report, Clause 3.0 of section III. The density of the compacted backfill material may further be verified to the satisfaction of the Owner based on the sand-cone method described in the ASTM D1556-82 standard.

39.12.3 The backfilling and grading shall be carried to an elevation of about 75mm above the finished ground level to drain out water. After backfilling 50mm high, earthen embankment (band) will be made along the sides of excavation pits and sufficient water will be poured in the backfilling earth for at least 24 hours. After the pits have been backfilled to full depth the stub template can be removed.

39.13 Benching

When the line passes through hilly/undulated terrain, levelling the ground may be required for casting of tower footings at no extra cost to the Employer. All such activities shall be termed benching and shall include cutting of excess earth and removing the same to a suitable point of disposal as required by Owner. Benching shall be resorted to only after approval from Owner. Volume of the earth to be cut shall be measured before cutting and approved by Owner for payment purposes.

Further, to minimise benching, unequal leg extensions shall be considered and provided if found economical. The proposal shall be submitted by the Contractor with detailed justification to the Owner.

39.14 Protection of Tower and Tower Footing

39.14.1 Tower shall be spotted such that the quantity of revetment are optimum. For tower locations in undulated terrain such as hill / mountain slopes, options like use of unequal leg extensions for towers, unequal chimney extensions etc. Shall be explored by the contractor for optimizing the need for revetment & benching.

39.14.2 The work shall include all necessary stone revetments, concreting and earth filling above ground level, the clearing from site of all surplus excavated soil, special measures for protection of foundation close to or in nalas, river bank / bed, undulated terrain, protection of up hill / down hill slopes required for protection of tower etc., including suitable revetment or galvanised wire netting and meshing packed with boulders. The top cover of stone revetment shall be sealed with M-15 concrete (1:2:4 mix). Contractor shall recommend protection at such locations wherever required. Details of protection of tower/tower footing are to be prepared by contractor duly approved by Employer.

39.14.3 Tower footings shall generally be backfilled using soil excavated at site unless unsuitable for backfilling. In the latter case, backfilling shall be done with borrowed earth of suitable quality irrespective of leads and lift. The unit rate for backfilling quoted shall include the required lead and consolidation and levelling of earth after backfilling.

39.14.4 The quantities for protection work of foundations are provisional only. The unit rates shall also be applicable for any quantity variations during execution. The same unit rates shall hold good for protection work carried out on down hills or up hills slopes applicable for the tower locations.

39.14.5 The unit rates for random rubble masonry revetment quoted in price schedule shall also include excavation & (1:6) random masonry and unit rate for top sealing with M-15 concrete. For payment purposes the volume of random rubble masonry revetment shall be measured from bottom to top sealing coat and paid at the unit rates indicated in the Letter Of Award. No extra payment shall be made for allied works such as excavation for revetment, packed stone at head of weep holes etc. However, no deduction shall be made for the volume enclosed by weep holes.

39.14.6 For some of the locations in nalas, river bed or undulated terrain etc., boulders of minimum. 150mm size bounded and packed in galvanised wire net/mesh of 8 SWG wire and 152 square (maxm.) mesh are to be provided. These stones shall be provided in crates size of 2.0mx2.0m or as deemed suitable for a particular location. Measurement shall be taken in cubic meters and 15% deduction will be made for void from cage/stack measurements.

39.15 CONSTRUCTION OF BORED CAST IN-SITU-PILE FOUNDATION

The contractor shall refer to clause 38.3 of chapter 38.

CHAPTER 40: ERECTION OF TRANSMISSION TOWER

TECHNICAL SPECIFICATIONS FOR ERECTION OF TRANSMISSION LINES

40.01 INDIAN STANDARDS/ CODE :

The material and services under this section shall conform to the requirements of the latest revisions and amendments available at the time of placement of order of all the relevant Indian standards/codes listed here under or equivalent International Standards, except as modified in this document.

S.No.	Indian standards	Title
1	IS:5613-1995 (part-II)	Code of practice for design, installation and maintenance of overhead power lines. Sec.-1 - Designs. Sec.-2 - Installation & Maintenance
2	IS:269-1967	Ordinary rapid hardening and low heat Portland cement.
3	IS:456-2000	Code of practice for plain and reinforced concrete
4	IS:1786-1966	Cold twisted steel bars for concrete reinforcements
5	IS:4091-1967	Code of practice for design & construction of foundation for transmission line towers & poles

40.02 LINE MATERIALS:

40.02.1 Conductor:

The Conductor used in the line will be ACSR Moose Conductor. The Conductor size is 54/3.53mm A1. + 7/3.53 mm Steel.

40.02.2 Ground-wire (OPGW):

The Ground-wire to be used on the line shall be 7/3.66 mm; 95 kg/mm2 quality galvanized steel stranded wire.

For OPGW please refer to chapter 43.

40.02.3 Insulator Strings with Hardware Fittings:

(i) Single suspension and double tension strings will be used on the line as under:

(a) At Suspension Locations:

23 Disc single suspension strings having 120KN E&MS of 255x145 mm size Disc Insulators with AGS type clamps will be used.

(b) At Tension Locations :

i. 24 Disc double tension strings with 160 KN E&MS Disc insulators of 280x170 mm size Disc Insulators will be used with compression type dead end clamp.
ii. Pilot strings will be used at deep angle tower locations for restraining the swing of jumpers.
iii. In cases of Railway/Road/River/Other transmission line crossings, double suspension insulator strings will be used.

40.02.4 Conductor Accessories:

(i) AGS (armour grip suspension) type suspension clamps shall be used with suspension strings.

(ii) Vibration Dampers (4-R type) and Spacers or Spacer-Dampers shall be used for Conductors.

40.02.5 Miscellaneous Items:

Enamelled Number Plates, Phase Plates and Danger Board, Bolts and Nuts, Spring washers, Pack washers and other tower accessories like 'D' Shackle, Hanger, U-Bolts and fasteners etc., shall be provided with the tower by the Contractor. The Contractor shall supply anticlimbing device (including Barbed wire) separately. Copper earth bond will be used for connecting Ground wire suspension and tension clamp with tower body, which shall also be provided by the Contractor.

40.03 APPROVED PROFILE:

(Applicable for check survey only)

40.03.1 The detailed survey has been conducted by the Purchaser or any other agency appointed by the Purchaser and the profiles shall be handed over to Contractor progressively for carrying out check survey and submission of profiles for approval of the purchaser. The profiles shall be prepared on cm. graph paper on scale 1:2000 horizontal and 1:200 vertical.

40.03.2 The route alignment surveyed by the Purchaser shall be marked at angle points. At angle points concrete blocks shall be provided and in the straight alignment marking will be done by pegs.

40.03.3 The Contractor will be responsible for the correct setting of towers as shown in approved profiles. If towers after erection are found to be out of the approved alignment/position in the profile, the Contractor will dismantle and re-erect them correctly fully at his own cost and without extension of time.

40.04 INSULATOR HOISTING:

Suspension insulator strings shall be used on suspension towers and tension insulator strings on angle and dead-end towers. They shall be fixed on all the towers just prior to the stringing. Damaged Insulators and fittings, if any, shall not be used in the assemblies. Before hoisting, all Insulators shall be cleaned in a manner that will not spoil, injure or scratch the surface of the Insulator, but in no case shall any oil be used for the purpose. Security clips shall be fitted in position for the Insulators before hoisting. Arcing Horns shall be fitted in an approved manner. Torque wrench shall be used for fixing different line materials and their components, like suspension clamps etc. For Conductor and Ground-wire etc.

40.05 HANDLING OF CONDUCTOR AND EARTHWIRE:

40.05.1 The Contractor shall be entirely responsible for any damage caused to the towers or Conductors during stringing. While running out the Conductors, proper care shall be taken ensuring that the Conductors do not touch and rub against the ground or objects which could cause scratches or damage to the Conductor strands. The Conductors shall be run out of the drums from the top in order to avoid damage due to chafing. The drum stand shall be provided with a suitable braking device to avoid damage, loose running out and kinking of Conductor. Proper care shall be taken to avoid injury to Conductor while making it pass over the bull wheel of tensioner. After the tensioner, the Conductor will be pulled by pull cable and consequently pass over the running out blocks. The groove of the running out blocks will be of such a design that the seat is semi-circular and larger than the diameter of the Conductor and it does not slip over or rub against the sides. The grooves shall be lined with hard rubber or neoprene to avoid damage to Conductor and shall be mounted on properly lubricated bearings.

40.05.2 The running blocks shall be suspended in a manner to suit the design of the cross arm. All running out blocks especially those at the tensioning end, will be fitted on the cross arm with jute cloth wrapped over the steel work and under the slings to avoid damage to the slings as well as to the protective surface finish of the steel work. The Conductor shall be continuously observed for loose or broken strands or any other kind of damage. When approaching towards end of a drum length, at least three coils shall be left when the stringing operations are to be stopped. These coils are to be removed carefully if another length is required to be run out, new length may be joined to the length already run out by the compression joint in approved manner. The Conductor joints and clamps shall be erected in such a manner that no bird caging, over tensioning of individual wires or layers or other deformities or damage to the conductor shall occur. Clamps or bracing devices shall under erection conditions allow no relative movement of strands or layers of the conductors.

40.05.3 Repairs of Conductors, in the event of damage being caused to isolated strands of a conductor during the course of erection, if necessary, shall be carried out during the running out operations, with repair sleeves. Repairing of Conductor surface with repair sleeve shall be done only in case of minor damage, scuff marks etc., keeping in view both electrical and mechanical safety requirements. Number of damaged strands shall not exceed $1/6^{th}$ of the total strands in the outer layer. The final Conductor surface shall be clean, smooth and shall be without any projections, sharp points, cuts, abrasions etc. Repair sleeves may be used when the damage is limited to the outermost layer of the Conductor and is equivalent to the severance of not more than one third of the strands of the outermost layer. No repair sleeve shall be fitted within 30 m of tension or suspension clamp or fittings. Further, more than one repair sleeve per Conductor shall not be normally used in any single span.

40.05.4 Conductor splices shall be so made that they do not crack or get damaged in the stringing operation. The Contractor shall use only such equipment/ methods during Conductor stringing which ensures complete compliance in this regard.

40.05.5 Derricks shall be used where roads, rivers, canals, telecommunication or overhead power lines, railway lines, fences or walls have to be crossed during stringing operations. It shall be seen that normal services are not interrupted, and no damage is caused to property. Shut down shall be obtained when working at crossing of overhead power lines.

40.05.6 The sequence of running out shall be from top to downwards, i.e. the Ground-wire shall be run out first followed by the Conductors in succession. Imbalances of loads on towers shall be avoided as far as possible i.e. both Ground-wires, then both bundles of top Conductor and then both bundles of middle Conductor followed by both bundle Conductors of bottom Cross-arm should be strung.

40.05.7 The proposed transmission line may run parallel for certain distance with the existing 400/220/132KV lines which will remain energized during the stringing period. As a result, there is a possibility of dangerous voltage build up due to electromagnetic and electrostatic coupling in the pulling cables, Conductors and Ground-wires, which although comparatively small in magnitude during normal operations, can be severe during switching and ground fault conditions on the energised lines. It shall be the Contractor’s responsibility to take adequate safety precautions to protect his employees and others from this potential danger.

40.06 STRINGING OF CONDUCTOR AND EARTHWIRE:

40.06.1 The stringing of the Conductor shall be done by control in tension method by means of tension stringing equipments. The equipments shall be capable of maintaining a continuous tension. The maximum tension imposed on a conductor during stringing operations shall not exceed than that necessary to clear obstructions on the ground. The contractor shall indicate in their offer, the sets of tension stringing equipment he is having in his possession and the sets of stringing equipment he would deploy exclusively for this work.

40.06.2 After being pulled, the Conductor/Ground-wire shall not be allowed to hang in the stringing blocks for more than 96 hours before being pulled to the specified sag.

40.06.3 The Contractor shall give complete details of the stringing methods, which he proposes to follow. At least one month in advance of the commencement of stringing, the Contractor will submit the stringing charts for the Conductors and Ground-wire showing the initial and final sags and tension for various temperatures and spans, alongwith equivalent spans in the lines, for the approval of the purchaser. The stringing shall be carried out as per the stringing charts approved by the purchaser and in accordance with relevant IS. All the tolerances for the line shall conform to IS :5613 (Part-2/Sec-2) 1995.

40.06.4 In hilly terrain and thick forest, where deployment of tension stringing machine is not possible, manual stringing may be adopted after getting approval of Purchaser’s site Engineer. The contractor shall deploy appropriate tools/equipments/machinery to ensure that the stringing operation is carried out without causing damage to conductor/earth wire and conductor/earth wire is installed at the prescribed sag-tension as per the approved stringing charts.

40.07 JOINTING:

40.07.1 The number of joints in Conductor/Ground-wire shall be kept to minimum possible by properly selecting the drums from available lot of respective drums. All the joints on the Conductor and Ground-wire shall be of compression type. Each part of the joint shall be cleaned by wire brush to make it free of rust or dirt etc. and properly greased with anti-corrosive compound, as approved by our Engineer before the final compression is done with the compressors. The cost of such grease etc. used for joints shall not be paid extra and shall be deemed to be included in the stringing rates.

40.07.2 All joints shall be made at least 30 meters away from the structures. No joints shall be made in the spans crossing over the main roads, railways, rivers etc. Not more than one joint per Conductor shall be allowed in one span. Care shall be taken to mark the conductor for properly centering the compression clamp before compressing. During compression operation, the conductor shall be handled in such a manner as to prevent lateral or vertical bearing against the dies. After pressing the joint the aluminium sleeve shall have all corners rounded, burrs and sharp edges removed and smoothened.

40.07.3 Suitable protector shall be used during stringing of Conductor to avoid any damage to the joint while it passes over the 1034raveller.

40.08 SAGGING IN OPERATION:

40.08.1 The Conductors shall be pulled up to the desired sag and left in running block for at least one hour after which the sag shall be rechecked and adjusted, if necessary, before transferring the conductor from the running out blocks to the suspension clamps. The Conductors shall be clamped within 36 hours of sagging in.

40.08.2 The sag will be checked in the first and the last span of the section in case of sections up to eight spans and in one intermediate span also for sections with more than eight spans. The sag shall also be rechecked when the Conductor have been drawn up and transferred from running blocks to the insulator clamps.

40.08.3 The running out blocks, when suspended from the transmission structure for sagging shall be so adjusted that the Conductors on running out blocks will be at the same height as that of the suspension clamps to which it is to be secured.

40.08.4 At sharp vertical angles, the sags and tensions shall be checked on both sides of the angle. The Conductor and Ground-wire shall be checked on the running out blocks for equality of tension on both sides. The suspension insulator assemblies will normally assume vertical positions when the Conductor is clamped.

40.08.5 Tensioning and sagging operations shall be carried out in calm weather, when rapid changes in temperature are not likely to occur.

40.09 TENSIONING & SAGGING OF CONDUCTOR AND EARTHWIRE:

The tensioning and sagging shall be done in accordance with the approved stringing charts before the Conductor and Ground-wire is finally attached to the towers through the insulator strings for the Conductor and Ground-wire clamps for the Ground-wire Dynamometers shall be used for measuring tension in the Conductor and Ground-wire.

40.10 CLIPPING IN:

40.10.1 Clipping of the Conductors in position shall be done in accordance with the method approved by our Engineer. At suspension location free center type suspension clamp with Armour rod set or AGS type suspension clamp shall be used.

40.10.2 The jumpers at the section and angle towers shall be formed to parabolic shape to ensure maximum clearance requirements. Pilot suspension insulator string shall be used, if necessary, to restrict the jumper swings to the design values. Jumper connections of transposition towers shall be so made that adequate clearances are available from tower body as well as phase conductors.

40.10.3 Fasteners in all fittings and accessories shall be secured in position. The security clip shall be properly opened and sprung into position.

40.11 FIXING OF CONDUCTORS AND EARTHWIRE ACCESSORIES:

Spacers, spacer dampers, Vibration dampers (4-R type) and other Conductor and Ground-wire Accessories supplied by the purchaser shall be installed by the Contractor as per the design/drawing requirement and as per instructions of the Engineer. Spacers shall be fitted within 24 hours of the Conductor clamping. While installing the Conductor and Ground-wire Accessories, proper care shall be taken to ensure that the surfaces are clean and smooth and no damage shall occur to any part of the Accessories.

40.12 REPLACEMENT:

If any replacements are to be affected after stringing and tensioning or during maintenance, members and bracing shall not be removed without reducing the tension on the tower with proper guying or releasing the Conductor. If the replacement of cross arms becomes necessary after stringing, the Conductor shall be suitably tied to the tower at tension points or transferred to suitable roller pulleys at suspension points.

40.13 FINAL CHECKING TESTING AND COMMISSIONING:

After completion of the works, final checking of the line shall be done by the Contractor to ensure that all the foundation works, tower erection, and stringing have been done strictly in accordance with the specification and as approved by the purchaser. All the works shall be thoroughly inspected keeping in view the following main points:

(a) Sufficient back-filled earth is lying over each foundation pit and it is adequately compacted.

(b) Concrete chimneys and their copings are in good finely shaped conditions.

(c) All the tower members are correctly used, strictly according to approved drawing and are free from defects or damages, whatsoever.

(d) All bolts are properly tightened and punched/tack welded as per this specification.

(e) The stringing of the Conductors and Ground-wire has been done as per the approved sag and tension charts and desired clearances are clearly available.

(f) All Conductor and Ground-wire Accessories are properly installed.

(g) All other requirements to complete the work like fixing of Danger Plate, Phase Plate, Number Plate, Anti-climbing devices, Aviation Signal (wherever required) etc. are properly installed and the painting has been done wherever required as per Aviation Rules.

(h) It should be ensured that revetment is provided, wherever required.

(i) The line insulation is tested by the Contractor by providing his own equipment labour etc. to the satisfaction of the purchaser to ascertain the insulation condition of the line.

(j) Conductor continuity test is carried out to verify that each Conductor of the overhead line is properly connected electrically also.

The line may be charged at a low value of Power Frequency Voltage for the purpose of testing.

CHAPTER 41: TECHNICAL SPECIFICATION AAAC CONDUCTORS AND ACCESSORIES FOR CONDUCTOR

41.1.0 SCOPE

41.1.1 This Section of the Specification covers the technical parameters for design, manufacture, testing at manufacturer's works and supply of Conductor and accessories for Power Conductors.

41.2.0 POWER CONDUCTOR

41.2.1 TYPE OF CONDUCTOR

The Power Conductor shall be stranded, 37/4.00 mm size (AAAC Zebra) and 37/3.15mm size (AAAC Panther) all aluminium alloy conductor (AAAC) conforming to IS: 398, Part-IV.

Conductor conforming to a standard other than the Indian Standard specification then an English version of the Standard in addition to the original standard if written in a language other than English should be submitted indicating clearly the advantage, if any, that would be obtained by the Employer for adopting this standard instead of the said India Standard.

41.2.2 TECHNICAL PARTICULARS

All Aluminium Alloy Conductor shall satisfy all the parameters as furnished in Technical Data Sheet.

41.2.3 MATERIAL

All Aluminium Alloy Conductor shall be stranded consisting of heat treated aluminium magnesium silicon alloy wires (Strands) containing approximately 0.5% magnesium and approximately 0.5% silicon.

41.2.4 JOINTS IN WIRE

In conductors containing more than seven wires, joints in individual wires are permitted in any layer except the outermost layer (in addition to those made in the brass rod or wire before final drawing) but no two such joints shall be less than 15 m apart in the complete stranded conductor, such joint shall be made by resistance or cold pressure butt welding. They are not required to fulfil the mechanical requirement of un-jointed wires. Joints made by resistance butt welding shall, subsequent to welding, be annealed over a distance of at least 200 mm on each side of the joint.

41.2.5 STRANDING

The wires used in construction of a stranded All Aluminium Alloy Conductor (AAAC) shall, before and after stranding, satisfy all requirements as per IS 398 (Part-IV).

The lay ratio of the different layers shall be with in the limits as per the said Standard.

In all constructions, the successive layers shall have opposite directions of lay, the outer most layer being right-handed. The wires in each layer shall be evenly and closely stranded.

In aluminium alloy stranded conductors having multiple layers of wires, the lay ratio of any layer shall not be greater than the lay ratio of the layer immediately beneath it.

41.2.6 ROUTINE/ACCEPTANCE TESTS

The samples of individual wires for the test shall normally be taken before stranding. The manufacture shall carry out test on samples taken out at least from 10 % of the aluminium wire spools. However, when desired by the Employer, the test sample may be taken from the stranded wires. The wires used for alloy conductors shall comply with the following tests as per IS: 398 –Part - IV) (amended up to d):

i) Breaking load test

ii) Elongation test

iii) Resistance test.

41.2.7 REJECTION AND RETESTS

Stipulations made in the IS 398 (Part-IV) on Rejection and Retests shall be followed.

41.2.8 PACKING

10.2.8.1 All conductor reels shall conform to latest edition of IS : 1778 and be of dimensions approved by the Employer and made of seasoned wood sufficiently strong to ensure arrival at site, intact withstanding normal handling and hazards inland and ocean transit. The reels shall be of such size as to provide at least 12.5 mm clearance at all points from the conductor to the inner surface of the laggings.

10.2.8.2 All reels shall have two coats of aluminium paint on both inside and outside surface and shall be fitted with malleable iron Hub-bushings.

10.2.8.3 All reels shall be a layer of waterproof paper around the hub under the cable and another layer over the outermost layer of the cable, that is next to the lagging.

10.2.8.4 The reels shall be properly reinforced with galvanized steel wires or iron straps over the lagging in two places in an approved manner.

10.2.8.5 The wooden drums shall preferably be given protective coating of a reliable organic wood preservative before painting with Aluminium paint and the laggings shall also be given a similar treatment before being fixed on the drum. There shall be one standard length of Conductor in each drum.

41.2.9 **TECHINCAL DATA SHEET FOR CONDUCTOR**

AAAC Zebra

Sl. No	DESCRIPTION	PARTICULARS
I	II	III
1	Type of Conductor	All Aliminium Alloy Conductor (AAAC), Stranded
2	No of Strand x size	37 x 4.00 mm
3	Conductor over all diameter	38.00 mm
4	Total sectional area	465 mm^2
5	Approx. weight	1280.5 kg/km
6	Minimum UTS	136.38 Kn
7	Modulus of Elasticity (Final)	0.5814 kg/cm^2
8	Coefficient of linear expansion	23.0 x 10^{-6} /^{0}C
9	Calculated maximum resistance/Km of Conductor at 20°C	0.0734 ohms/km
10	Particulars of Aluminium Alloy Wires (strands)	
	(a) Wire Diameter (i) Standard: (ii) Maximum: (iii) Minimum:	 4.00 mm 4.04 mm 3.96 mm
	(b) Resistivity of wire	0.0328 ohms.mm^2/m
	(c) Density	2.70 kg/dm^2
	(d) Co-efficient of Linear expansion	23.0 x 10^{-6} /^{0}C
	(e) Cross Sectional area of Aluminium wire	12.57 mm^2
	(f) Approximate Total weight of each strand	33.93 kg/km
	(g) Calculated resistance at 20°C (D.C.)	2.663 ohm/km
	(h) Minimum Breaking Load of each strand	4.40 Kn – before stranding 4.18 Kn – after stranding

AAAC PANTHER

Sl. No	DESCRIPTION	PARTICULARS
		IV
1	Type of Conductor	All Aliminium Alloy Conductor (AAAC), Stranded
2	No of Strand x size	37 x 3.15 mm
3	Conductor over all diameter	22.05 mm
4	Total sectional area	288 mm^2
5	Approx. weight	794.05 kg/km
6	Minimum UTS	84.71 kN
7	Modulus of Elasticity (Final)	0.5814 kg/cm^2
8	Coefficient of linear expansion	23.0 x 10^{-6} /^{0}C
9	Calculated maximum resistance/Km of Conductor at 20°C	0.1182 ohms/km
10	Particulars of Aluminium Alloy Wires (strands)	
	(i) Wire Diameter (iv) Standard: (v) Maximum: (vi) Minimum:	 3.15mm 3.18 mm 3.12 mm
	(j) Resistivity of wire	0.0328 ohms.mm^2/m
	(k) Density	2.70 kg/dm^2
	(l) Co-efficient of Linear expansion	23.0 x 10^{-6} /^{0}C
	(m) Cross Sectional area of Aluminium wire	7.793 mm^2
	(n) Approximate Total weight of each strand	21.04 kg/km
	(o) Calculated resistance at 20°C (D.C.)	4.290 ohm/km
	(p) Minimum Breaking Load of each strand	2.41 kN – before stranding 2.29 kN – after stranding

41.3.0 GROUND WIRES

Optical ground wire (OPGW) shall be used as per chapter 43.

41.4.0 FITTINGS AND ACCESSORIES FOR CONDUCTORS

41.4.1 The accessories for conductors shall conform to IS: 2121 and 2486 (Latest version) in all respects.

41.4.2 The tension joints and repaired sleeves in the conductors shall be of compression type. The joints shall be such that in electrical resistance of the joints measured between two points just beyond the fittings shall not exceed 75% of that of an equivalent length of the conductor without joint and shall be capable to withstand a load of 95% of the breaking load of the conductor itself.

41.4.3 The non tension joints such as the parallel groove clamps shall conform to IS 2121 and should be able to withstand a load of 10% of the breaking load of conductor without any slip.

41.4.4 Preformed type armoured rods shall be provided for the conductors at all suspension points. Vibration dampers of stock bridge type shall be used for power conductors.

41.5.0 FITTINGS AND ACCESSORIES FOR GROUND WIRES

Fittings and accessories for OPGW shall be used as per chapter 46.

CHAPTER 42: TECHNICAL SPECIFICATION ACSR CONDUCTORS AND ACCESSORIES FOR CONDUCTORS

42.1.0 SCOPE

42.1.1 This Section of the Specification covers the technical parameters for design, manufacture, testing at manufacturer's works and supply of Conductor, and accessories for Power Conductors.

42.2.0 POWER CONDUCTOR

42.2.1 TYPE OF CONDUCTOR

The ACSR Conductor shall generally conform to IEC: 61089/ IS: 398 (relevant part)/ ASTM:B-232 except where otherwise specified herein.

Conductor conforming to a standard other than the Indian Standard specification then an English version of the Standard in addition to the original standard if written in a language other than English should be submitted indicating clearly the advantage, if any, that would be obtained by the Employer for adopting this standard instead of the said India Standard.

42.2.2 STANDARD TECHNICAL PARTICULARS

All ACSR Conductor shall satisfy all the parameters as furnished in Technical Data Sheet.

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 and also after stranding.

The steel strands shall be hot dip galvanised and shall have a minimum zinc coating.

42.2.3 MATERIAL

43.2.3.1 The aluminium strands shall be hard drawn from electrolytic aluminium rods having purity and copper content as per the values indicated in the STP. They shall have the same properties and characteristics as prescribed in IEC: 60889.

43.2.3.2 The steel wire strands shall be drawn from high carbon steel wire rods produced by either the acid or the basic open-hearth process, the electric furnace process, or the basic oxygen process and shall conform to the chemical composition indicated in the STP.

43.2.3.3 The Steel wire strands shall have the same properties and characteristics as prescribed for regular strength steel wire in IEC : 60888.

43.2.3.4 The zinc used for galvanizing shall be electrolytic High Grade Zinc of purity. It shall conform to and satisfy all the requirements of IS:209.

42.2.4 JOINTS IN WIRE

In the Aluminium wires no joints shall be permitted in the individual wires in the outer most layer of the finished conductor. However, joints are permitted in the inner layer of the conductor unavoidably broken during stranding provided such breaks are not associated with either inherently defective wire or with the use of short lengths of aluminium wires. Such joints shall not be more than four (4) per conductor length and shall not be closer than 15 meters from joint in the same wire or in any other aluminium wire of the completed conductor.

Joints shall be made by cold pressure butt welding and shall withstand a stress of not less than the breaking strength of individual strand as per STP.

In the 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.

42.2.5 STRANDING

The wires used in construction of a ACSR conductor shall, before and after stranding, satisfy all requirements as per IS 398.

The lay ratio of the different layers shall be within the limits as per the said Standard. In all constructions, the successive layers shall have opposite directions of lay, the outer most layer being right-handed. The wires in each layer shall be evenly and closely stranded. In aluminium alloy stranded conductors having multiple layers of wires, the lay ratio of any layer shall not be greater than the lay ratio of the layer immediately beneath it.

42.2.6 TYPE/ROUTINE/ACCEPTANCE TESTS

Type Test:

The following tests shall be conducted on a sample/samples of the conductor(s) required under the package from each stranding machine from which the conductor is to be manufactured & supplied:

a) DC resistance test on stranded conductor
b) UTS test on stranded conductor
c) Corona extinction voltage test (dry)
d) Radio interference voltage test (dry)

Acceptance Test:

a) Visual and dimensional check on drum
b) Visual check for joints, scratches etc. and length measurement of conductor by rewinding
c) Measurement of diameters of individual Steel and Aluminium strands

4. Galvanizing test on steel strands
5. Check for lay Ratios of various layers
6. Torsion and Elongation tests on steel strands
7. Breaking load test on steel and Aluminium strands
8. Wrap test on Steel & Aluminium strands
9. DC resistance test on Aluminium strands
10. Procedure qualification test on welded joint of Aluminium strands
11. Drum strength test (steel drum)
12. Barrel Batten strength test (wooden drum)

The above acceptance tests shall be repeated on one conductor sample taken from site in presence of AEGCL's representative for each 500km progressive supply. The tests shall be carried out by the supplier at his cost at its own premises or any other tests centre having required facilities. The sample shall be selected by AEGCL's site representative and the tests shall be witnessed by AEGCL's representative.

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) Check that drums are as per Specification
d) All acceptance test as mentioned above to be carried out on aluminium and steel strands of 20% of drums

Tests During manufacture:

a) Chemical Analysis of Zinc used for galvanising
b) Chemical Analysis of Aluminium used for making Aluminium Strands
c) Chemical Analysis of Steel used for making Steel Strands.

42.2.7 REJECTION AND RETESTS

Stipulations made in the IS 398 (Part-IV) on Rejection and Retests shall be followed.

42.2.8 PACKING

All conductor reels shall conform to latest edition of IS : 1778 and be of dimensions approved by the Employer and made of seasoned wood sufficiently strong to ensure arrival at site, intact withstanding normal handling and hazards inland and ocean transit. The reels shall be of such size as to provide at least 12.5 mm clearance at all points from the conductor to the inner surface of the laggings.

All reels shall have two coats of aluminium paint on both inside and outside surface and shall be fitted with malleable iron Hub-bushings.

All reels shall be a layer of waterproof paper around the hub under the cable and another layer over the outermost layer of the cable, that is next to the lagging.

The reels shall be properly reinforced with galvanized steel wires or iron straps over the lagging in two places in an approved manner.

The wooden drums shall preferably be given protective coating of a reliable organic wood preservative before painting with Aluminium paint and the laggings shall also be given a similar treatment before being fixed on the drum. There shall be one standard length of Conductor in each drum.

42.2.9 TECHINCAL DATA SHEET FOR CONDUCTOR

ACSR MOOSE

Sl. No	DESCRIPTION	PARTICULARS
I	II	III
1	Type of Conductor	Aluminium Conductor Steel Reinforced (ACSR)
2	No of Strand x size	54 x 3.53 mm
3	Conductor over all diameter	31.77 mm
4	Total sectional area	597 mm^2
5	Approx. weight	2004 kg/km
6	Minimum UTS	161.2 kN
7	Modulus of Elasticity (Final)	0.7034 kg/cm^2
8	Coefficient of linear expansion	19.3×10^{-6} /^{0}C
9	Calculated maximum resistance/Km of Conductor at 20°C	0.05552 ohms/km
10	Layer and No of Wire	
	Steel core	1
	1st steel layer	6
	1st Aluminium layer	12
	2nd Aluminium layer	18
	3rd Aluminium layer	24
11	**Aluminum strands after stranding**	
(a)	Diameter	
	Nominal	3.53
	Maximum	3.55
	Minimum	3.51
(b)	Minimum breaking load of strand	
	Before stranding	1.57
	After stranding	1.49
12	**Steel strand after stranding**	
(a)	Diameter	
	Nominal	3.53
	Maximum	3.59
	Minimum	3.47
(b)	Minimum breaking load of strand	
	Before stranding	12.86
	After stranding	12.22
13	DC resistance of the conductor at 20°C	0.05552
14	Direction of lay of outer layer	Right Hand
15	Linear mass of the conductor	
	Standard	2004
	Minimum	1969
	Maximum	2040

ACSR Zebra

1.	Code Name	ZEBRA
2.	Equivalent area of Aluminium (sq.mm.)	418.6
3.	Wire Strand (Al./Steel)	54/7
4.	Nominal diameter of strand (Al./Steel)(mm.)	3.18/3.18
5.	Weight (Kg/Km)	1621
6.	Co-eff. of linear expansion per ^{o}C	19.30×10^{-6}
7.	Ultimate Tensile Strength (kgf.)	13316
8.	Maxm. DC resistance at $20^{o}C$ (□/Km) (Calculated from maxm. Value of resistivity and min. Cross-sectional area)	0.0680
9.	Zinc coating of steel :	
	i) No. of one minute dip	3
	ii) Min. wt. of zinc.($gm.m^{2}$)	260
	iii) Purity of zinc (%)	99.95
10.	Diameter of conductor (mm)	28.62
11.	Standard Length (meter)	1100

ACSR Panther

Sl. No.	DESCRIPTION	ACSR 'PANTHER'
1	Code name	PANTHER
2	Number of strands & size	Al: 30/ 3.00 mm St: 7/ 3.00 mm
3	Overall diameter	21.00 mm
4	Breaking load	130.32 kN
5	Weight of conductor	974 kg / km
6	Co-efficient of linear expansion	19.35×10^{-6} /^{0}C
7	Number of strand	
	Steel centre	1

	1st Steel Layer	6
	1st Aluminium Layer	12
	2nd Aluminium Layer	18
	3rd Aluminium Layer	-
8	Sectional area of Aluminium	212.10 mm^2
9	Total sectional area	261.50 mm^2
10	Calculated d.c. resistance at 20^0 C	0.1400 ohm/km
11	Ultimate tensile strength	89.67

42.3.0 GROUND WIRES

Optical ground wire (OPGW) shall be used as per chapter 47.

42.4 FITTINGS AND ACCESSORIES FOR CONDUCTORS

The accessories for conductors shall conform to IS: 2121 and 2486 (Latest version) in all respects

➢ **Mid Span Compression Joint**

- Mid Span Compression Joint shall be used for joining two lengths of conductor. The joint shall have a resistivity less than 75% of the resistivity of equivalent length of conductor. The joint shall not permit slipping off, damage to or failure of the complete conductor or any part there of at a load less than 95% of the ultimate tensile strength of the conductor.
- The joint shall be made of steel and aluminium sleeves for jointing the steel core and aluminium wires respectively. The steel sleeve should not crack or fail during compression. The steel sleeve shall be hot dip galvanised. The aluminium sleeve shall have aluminium of purity not less than 99.5%. The dimensions and dimensional tolerances of mid span compression joint shall be as per Standard Technical Particulars.

➢**T-Connector**

T-Connector of compression type shall be used for jumper connection at transposition tower. It shall be manufactured out of 99.5% pure aluminium and shall be strong enough to withstand normal working loads. The T-connector shall have a resistivity across jumper less than 75% resistivity of equivalent length of conductor. The T-connector shall not permit slipping off, damage to or failure of complete conductor. The welded portions shall be designed for 30 kN axial tensile load. Leg sleeve of T-connector should be kept at an angle of 15 deg. from vertical and horizontal plane of the conductor in order to minimise jumper pull at the welded portion. The dimensions and dimensional tolerances of T-connector shall be as per Standard Technical Particulars.

➢**Repair Sleeve**

Repair Sleeve of compression type shall be used to repair conductor with not more than two strands broken in the outer layer. The sleeve shall be manufactured from 99.5% pure aluminium and shall have a smooth surface. The repair sleeve shall comprise of two pieces with a provision of seat for sliding of the keeper piece. The edges of the seat as well as the keeper piece shall be so rounded that the conductor strands are not damaged during installation. The dimensions and dimensional tolerances of repair sleeve shall be as per Standard Technical Particulars.

➢**Vibration Damper (Applicable for 400kV D/C (Twin Moose), 220kV & 132kV Lines)**

- Vibration dampers of 4R-stockbridge type with four (4) different resonances spread within the specified Aeolian frequency band width corresponding to wind speed of 1 m/s to 7 m/s shall be used at suspension and tension points on each conductor in each span along with bundle spacers to damp out Aeolian vibration as mentioned hereinafter.
- Alternate damping systems or “Dogbone” dampers offering equivalent or better performance also shall be accepted provided the manufacturer meets the qualifying requirements stipulated in the Specifications. Relevant technical documents to establish the technical suitability of alternate systems shall be furnished by the Bidder along with the bid.
- One damper minimum on each side per Conductor/Sub-conductor for suspension points and two dampers minimum on each side per conductor/sub-conductor for tension points shall be used for ruling design span.
- The clamp of the vibration damper shall be made of high strength aluminium alloy of type LM-6. It shall be capable of supporting the damper and prevent damage or chafing of the conductor during erection or continued operation. The clamp shall have smooth and permanent grip to keep the damper in position on the conductor without damaging the strands or causing premature fatigue failure of the conductor under the clamp. The clamp groove shall be in uniform contact with the conductor over the entire clamping surface except for the rounded edges. The groove of the clamp body and clamp cap shall be smooth, free from projections, grit or other materials which could cause damage to the conductor when the clamp is installed. Clamping bolts shall be provided with self-locking nuts and designed to prevent corrosion of threads or loosening in service.
  - The damper mass shall be made of hot dip galvanised mild steel/cast iron or a permanent mould cast zinc alloy. All castings shall be free from defects such as cracks, shrinkage, inclusions and blowholes etc. The surface of the damper masses shall be smooth.
  - The damper clamp shall be casted over the messenger cable and offer sufficient and permanent grip on it. The messenger cable shall not slip out of the grip at a load less than the mass pull-off value of the damper. The damper masses made of material other-than zinc alloy shall be fixed to the messenger cable in a suitable manner in order to avoid excessive stress concentration on the messenger cables which shall cause premature fatigue failure of the same. The messenger cable ends shall be suitably and effectively sealed to prevent corrosion. The damper mass made of zinc alloy shall be casted over the messenger cable and have sufficient and permanent grip on the messenger cable under all service conditions.
  - Preformed type armoured rods shall be provided for the conductors at all suspension points. Vibration dampers of stock bridge type shall be used for power conductors.

➢**Bundle Spacer (for Twin Bundle Conductor) & Rigid Spacer (for Hexa/Quad / Triple/ Twin Bundle Conductor)**

- Armour grip bundle spacers shall be used to maintain the spacing of 450 mm (for 400 kV voltage level line twin bundle conductor) between the two sub-conductors of each bundle under all normal working conditions.

- Spacers offering equivalent or better performance shall also be accepted provided offer meets the qualifying requirements stipulated in the Specification.
- The placement of spacers shall be in such a way that adjacent sub spans are sufficiently detuned and the critical wind velocity of each sub span shall be kept more than 30 km/hr and to avoid clashing of sub conductors. The placement shall ensure bundle stability under all operating conditions.
- Spacer shall restore normal spacing of the sub conductors after displacement by wind, electromagnetic and the electrostatic forces under all operating conditions including the specified short circuit level without permanent deformation damage either to conductor or to the assembly itself. They shall have uniform grip on the conductor
- For spacer requiring retaining rods, the retaining rods shall be designed for the specified conductor size. The preformed rods shall be made of high strength, special aluminium alloy of type 6061/65032 and shall have minimum tensile strength of 35 kg/sq.mm. The ends of retaining rods should be ball ended. The rods shall be heat- treated to achieve specified mechanical properties and give proper resilience and retain the same during service.
- Four number of rods shall be applied on each clamp to hold the clamp in position. The minimum diameter of the rods shall be 7.87 + 0.1 mm and the length of the rods shall not be less than 1100 mm.
- Where elastomer surfaced clamp grooves are used, the elastomer shall be firmly fixed to the clamp. The insert should be forged from aluminium alloy of type 6061/65032. The insert shall be duly heat treated and aged to retain its consistent characteristics during service.
- Any nut used shall be locked in an approved manner to prevent vibration loosening. The ends of bolts and nuts shall be properly rounded for specified corona performance or suitably shielded.
- Clamp with cap shall be designed to prevent its cap from slipping out of position when being tightened.
- For the spacer involving bolted clamps, the manufacturer must indicate the clamp bolt tightening torque to ensure that the slip strength of the clamp is maintained between 2.5 kN and 5 kN. The clamp when installed on the conductor shall not cause excessive stress concentration on the conductor leading to permanent deformation of the conductor strands and premature fatigue failure in operation.
- Universal type bolted clamps, covering a range of conductor sizes, will not be permitted.
- The spacer shall be suitably designed to avoid distortion or damage to the conductor or to themselves during service.
- Rigid spacers shall be acceptable only for jumpers.
- The spacer tube shall be made of aluminium alloy of type 6061/65032 or 6063/63400. If fasteners of ferrous material are used, they shall conform to and be galvanised conforming to relevant Indian Standards. The spacer involving ferrous fasteners shall not have magnetic power loss more than that stipulated in the Standard Technical Particulars.
- Elastomer, if used, shall be resistant to the effects of temperature up to 95 deg.C, ultraviolet radiation and other atmospheric contaminants likely to be encountered in service. It shall have good fatigue characteristics. The physical properties of the elastomer shall be of approved standard.

- The spacer assembly shall have electrical continuity. The electrical resistance between the sub-conductor across the assembly in case of spacer having elastomer clamp grooves shall be suitably selected by the manufacturers to ensure satisfactory electrical performance and to avoid deterioration of elastomer under all service conditions.
- The spacer assembly shall have complete ease of installation and shall be capable of removal/reinstallation without any damage.
- The spacer assembly shall be capable of being installed and removed from the energised line by means of hot line technique.

42.5 FITTINGS AND ACCESSORIES FOR GROUND WIRES

Fittings and accessories for OPGW shall be used as per chapter 46.

CHAPTER 43: TECHNICAL SPECIFICATION FOR INSULATOR STRING HARDWARE

43.1.0 HARDWARE

Each insulator string assembly shall generally include the following hardware:

Anchor shackle for attachment of suspension string assembly to the tower hanger and tension string assembly to the tower strain plate. Suitable top and bottom yoke assemblies with the arrangement of fixing a set of arcing horns.

- Set of arcing horns
- Suspension or tension clamp
- Bolts, nuts, washers, split pins etc.
- Other fitting s necessary to make the strings complete such as ball clevis, socket clevis, chain links etc.

The tenderer shall be responsible and satisfy himself that all the hardware included in strings are entirely suitable for the conductor offered.

43.2.0 SUSPENSION CLAMP

The suspension clamps shall be made of malleable iron or aluminium alloy, hot dip galvanised and shall be suitable to accommodate the conductor together with one set of preformed armour rods. Suitable sheet aluminium liners shall be provided. The suspension clamps shall be designed to avoid any possibility of deforming or damaging the conductor. The lips shall be rounded off and the seating and the bell mouths shall be smooth to avoid corona and radio interference noises. The suspension clamps shall be suitable to carry the bottom part of the arcing horn and to receive the fittings of the insulator string.

The suspension clamps shall be such that the conductor should not slip at a load of 25% of the breaking load of the conductor. The ultimate strength of the clamp for vertical load shall not be less than the failing load of the Disc Insulators.

43.2.1 STRAIN CLAMP

The bolted strain clamps shall also be made of malleable iron or aluminium alloy; hot dip galvanised, lined with sheet aluminium liners and shall be suitable to accommodate the conductor with necessary binding tapes etc. The lips shall be rounded off carefully and conductor seating and the ball mouth shall be smooth to avoid corona and radio interference noises. Suitable attachment for receiving one side of arcing horns and for connecting to the insulator strings shall be provided.

The strain clamps shall be such that the conductor should not slip at a load of 90% of the breaking load of the conductor. The ultimate strength of the clamp for horizontal load shall not be less than the ultimate strength of the conductor

43.2.2 ARCING HORNS:

Arcing horns of approved size and dimensions shall be provided for every string of insulators. The performance data for arcing horns to be supplied shall be made available to the Employer.

43.2.3 OTHER INSULATOR STRING HARDWARE:

The strength of other string hardware namely anchor shackle, yoke plates, socket-clevis etc. shall be co-ordinated with insulator disc strength.

43.3.0 Interchangeability

The hardware together with ball and socket fittings shall be of standard design, so that this hardware is interchangeable with each other and suitable for use with disc insulators of any make con1orming to relevant Indian/International Standard.

43.4.0 Corona and RI Performance

Sharp edges and scratches on all the hardware fittings shall be avoided. All surfaces must be clean, smooth, without cuts and abrasions or projections. The Contractor/Manufacturer must give suitable assurance about the satisfactory corona and radio interference performance of the materials offered by him.

43.5.0 Maintenance

The hardware fittings offered shall be suitable for employment of hot line maintenance technique so that usual hot line operations can be carried out with ease, speed and safety. The technique adopted for hot line maintenance shall be generally bare hand method & hot stick method. The Bidder should clearly establish in the bid, the suitability of his fittings for hot line maintenance.

The line side yoke plate shall have a notch & a working hole of suitable size. The design of corona control rings/grading ring shall be such that it can be easily replaced by employing hot line maintenance technique.

43.6.0 Designation

Ball and Socket Designation

The dimensions of the ball and socket shall be 16 mm (Alt-B) designation for 70 KN &90KN Insulators, 20 mm designation for hardware with 120kN & 160 kN Insulators, in accordance with the standard dimensions stated in IS: 2486-(Part-II) /IEC:120. The dimensions shall be checked by the appropriate gauge after galvanising only.

43.7.0 Security Clips and Split Pins

43.7.1 Security clips for use with ball and socket coupling shall be R-shaped, hump type which provides positive locking 9f the coupling as per IS: 2486-(Part-III)/IEC: 372. The legs of the security clips shall be spread after assembly in the works to prevent complete withdrawal from the socket. The locking device should be resilient, corrosion resistant and of suitable mechanical strength. There shall be no risk of the locking device being displaced accidentally or being rotated when in position. Under no circumstances shall the locking devices allow separation of fittings.

43.7.2 The hole for the security clip shall be countersunk and the clip should be of such design that the eye of clip may be engaged by a hot line clip puller to provide for disengagement under energised conditions. The force required to pull the security clip into its unlocked position shall neither be less than 50 N (5 kg) nor more than 500 N (50 kg).

Split pins shall be used with bolts & nuts.

43.8.0 Arcing Horn for EHV Strings

43.8.1 The arcing horn shall be provided on tower side of the hardware fittings. The same shall be either ball ended rod type or tubular type.

43.8.2 The spark gap shall be so adjusted to ensure effective operation under actual field conditions.

43.9.0 Yoke Plates

• The strength of yoke plates shall be adequate to withstand the minimum ultimate tensile strength as specified in the bid drawings.

• The plates shall be either triangular or rectangular in shape as may be necessary. The design of yoke plate shall take into account the most unfavorable loading conditions likely to be experienced as a result of dimensional tolerances for disc insulators as well as components of hardware fittings within the specified range. The plates shall have suitable holes for fixing corona control rings/grading ring/arcing horn. All the corners and edges should be rounded off with a radius of atleast 3 mm. Design calculations i.e. for bearing & tensile strength, for deciding the dimensions of yoke plate shall be furnished by the Contractor/Manufacturer. The holes provided for bolts in the yoke plate should satisfy shear edge condition as per Clause No. 10.2.4.2 of IS:800-2007.

43.10.0 Corona Control Rings/Grading Ring (For 220 kV & above voltage level line)

- The Corona control rings/grading ring shall be provided with hardware fittings and shall be of such design that it should cover at least one disc insulator in disc insulator strings/ metal polymer junction point in composite insulator strings so that they will reduce the voltage across the insulator units. It shall also improve corona and radio interference performance of the complete insulator string along with hardware fittings.
- The corona control rings/grading ring shall be made of high strength heat treated aluminium alloy tube of minimum 2.5 mm wall thickness. If mild steel brackets are used then the brackets shall not be welded to the pipe but shall be fixed by means of bolts and nuts on a small aluminium plate attachment welded to the pipe. The welded center of the corona control ring/grading ring shall be grinded before buffing. Alternately, Aluminium tube/flats of suitable dimensions welded to the corona control rings/grading rings may be used for connection to yoke plate.
- The Corona control rings/grading ring should have a brushed satin finish and not a bright glossy surface. No blemish should be seen or felt when rubbing a hand over the metal.
- Bidder may quote for grading ring with armour grip suspension assembly. The grading ring shall be of open type design with a gap of 125 mm. The open ends shall be suitably terminated. The outside diameter of the tube shall be 75 mm. The ends of grading ring tube shall be sealed with welded aluminum cap duly buffed.

43.11.0 Sag Adjustment Plate (For 400 kV voltage level line)

- The sag-adjustment plate to be provided with the double tension hardware fitting (for 400kV (Twin) line) shall be of three plate type. The sag adjustment plate shall be provided with a safety locking arrangement. The device shall be of such design that the adjustment is done with ease, speed and safety.

- The maximum length of the sag adjustment plate from the connecting part of the rest of the hardware fittings shall be 520 mm. The details of the minimum and maximum adjustment possible and the steps of adjustment shall be clearly indicated in the drawing. An adjustment of 150 mm minimum at the interval of 6 mm shall be possible with the sag adjustment plate.
- Design calculations for deciding the dimensions of sag adjustment plate shall be furnished by Contractor/Manufacturer. The hole provided for bolts should satisfy shear edge condition as per Clause No. 10.2.4.2 of IS:800-2007.

43.12.0 Turnbuckle

43.12.1 The turn buckle is to be provided with single tension hardware fitting. The threads shall be of sufficient strength to remain unaffected under the specified tensile load.

43.12.2 The maximum length of the turn buckle from the connecting part of the rest of the hardware fittings shall be 380 mm for 132KV and 220KV Line and 520mm for 400KV Line. The details of the minimum and maximum adjustment possible shall be clearly indicated in the drawing submitted with the bid. An adjustment of 135 mm minimum for 132KV and 220KV Line and 150mm minimum for 400KV Line shall be possible with turnbuckle.

43.13.0 Suspension Assembly

43.13.1 The suspension assembly shall include free center type suspension clamp along with standard preformed armour rods or armour grip suspension clamp; except for Pilot insulator string for which only suitable Envelope type suspension clamp shall be used.

43.13.2 The suspension clamp along with standard preformed armour rods set shall be designed to have maximum mobility in any direction and minimum moment of inertia so as to have minimum stress on the conductor in the case of oscillation of the same.

43.13.3 The suspension assembly shall be designed, manufactured and finished to give it a suitable shape, so as to avoid any possibility of hammering between suspension assembly and conductor due to vibration. The suspension assembly shall be smooth and without any cuts, grooves, abrasions, projections, ridges or excrescence which might damage the conductor.

43.13.4 The suspension assembly/clamp shall be so designed so that it minimises the static and dynamic stress developed in the conductor under various loading conditions as well as during wind induced conductor vibrations. It shall also withstand power arcs and have required level of Corona/AIV performance.

43.14.0 Free Center Type Suspension Clamp

For the Free Center Suspension Clamp seat shall be smoothly rounded and curved into a bell mouth at the ends. The lip edges shall have rounded bead. There shall be at least two U-bolts for tightening of clamp body and keeper pieces together.

43.15.0 Standard Preformed Armour Rod Set

43.15.1 The Preformed Armour Rod Set suitable for Conductor shall be used to minimise the stress developed in the sub-conductor due to different static and dynamic loads because of vibration due to wind, slipping of conductor from the suspension clamp as a result of unbalanced conductor tension in adjacent spans and broken wire condition. It shall also withstand power arcs, chafing and abrasion from suspension clamp and localised heating effect due to magnetic power losses from suspension clamps as well as resistance losses of the conductor.

43.15.2 The preformed armour rods set shall have right hand lay and the inside diameter of the helices shall be less than the outside diameter of the conductor in order to gently but permanently grip the conductor. The surface of the armour rod when fitted on the conductor shall be smooth and free from projections, cuts and abrasions, etc.

43.15.3 The pitch length of the rods shall be determined by the Bidder but shall be less than that of the outer layer of conductor and the same shall be accurately controlled to maintain uniformity and consistently reproducible characteristic wholly independent of the skill of linemen.

43.15.4 The conductivity of each rod of the set shall not be less than 12% of the conductivity of the International Annealed Copper Standard (IACS).

43.16.0 Armour Grip Suspension Clamp

• The armour grip suspension clamp shall comprise of retaining strap, support housing, elastomer inserts with aluminum reinforcements and AGS preformed rod set.

• Elastomer insert shall be resistant to the effects of temperature up to 95oC, Ozone, ultraviolet radiations and other atmospheric contaminants likely to be encountered in service. The physical properties of the elastomer shall be of approved standard. It shall be electrically shielded by a cage of AGS performed rod set. The elastomer insert shall be so designed that the curvature of the AGS rod shall follow the contour of the neoprene insert.

• The length of the AGS preformed rods shall be such that it shall ensure sufficient slipping strength as specified in the Standard Technical Particulars and shall not introduce unfavourable stress on the conductor under all operating conditions.

43.17.0 Envelope Type Suspension Clamp

• The seat of the envelope type suspension clamp shall be smoothly rounded & suitably curved at the ends. The lip edges shall have rounded bead. There shall be at least two U-bolts for tightening of clamp body and keeper pieces together. Hexagonal bolts and nuts with split-pins shall be used for attachment of the clamp.

43.18.0 Dead End Assembly

43.18.1 The dead-end assembly shall be suitable for Conductor as detailed in the document.

43.18.2 The dead-end assembly shall be compression type with provision for comprising the jumper terminal at one end. The angle of the jumper terminal to be mounted should be 30º with respect to the vertical line. The area of bearing surface on all the connections shall be sufficient to ensure positive electrical and mechanical contact and avoid local heating due to I2R losses. The resistance of the clamp when compressed on Conductor shall not be more than 75% of the resistance of equivalent length of Conductor.

43.18.3 The assembly shall not permit slipping of, damage to, or failure of the complete conductor or any part thereof at a load less than 95% of the ultimate tensile strength of the conductor.

43.19.0 Fasteners: Bolts, Nuts and 'Washers

43.19.1 All bolts and nuts shall conform to IS: 6637. All bolts and nuts shall be galvanised as per IS-1367 -(Part 13)/IS-2629. All bolts and nuts shall have hexagonal heads, the heads being forged out of solid truly concentric, and square with the shank, which must be perfectly straight.

43.19.2 Bolts up to M16 and having length up to 10 times the diameter of the bolt should be manufactured by cold forging and thread rolling process to obtain good and reliable mechanical properties arid effective dimensional control. The shear strength of bolt for 5.6 grade should be 310 MPa minimum as per IS-12427. Bolts should be provided with washer face in accordance with IS: 1363 Part-1 to ensure proper bearing.

43.19.3 Nuts should be double chamfered as per the requirement of IS: 1363 Part-III. It should be ensured by the manufacturer that nuts should not be over tapped beyond 0.4 mm oversize on effective diameter for size up to M16

43.19.4 Fully threaded bolts shall not be used. The length of the bolt shall be such that the threaded portion shall not extend into the place of contact of the component parts.

43.19.5 All bolts shall be threaded to take the full depth of the nuts and threaded enough to permit the firm gripping of the component parts but no further .it shall be ensured that the threaded portion of the bolt protrudes not less than 3 mm and not more than 8 mm when fully tightened. All nuts shall fit and tight to the point where shank of the bolt connects to the head.

43.19.6 For parts/ components requiring grip strength viz. arcing horn, corona rings & dead-end jumper assembly, fully threaded bolts can be used as an alternative. Bolts & nuts for these parts/ components shall be of minimum 4.6 grade conforming to IS 6639 or equivalent International standards.

43.19.7 Flat washers and spring washers shall be provided wherever necessary and shall be of positive lock type. Spring washers shall be electro-galvanised. The thickness of washers shall conform to IS: 2016.

43.19.8 The Bidder shall furnish bolt schedules giving thickness of components connected, the nut and the washer and the length of shank and the threaded portion of bolts and size of holes and any other special details of this nature.

43.19.9 To obviate bending stress in bolt, it shall not connect aggregate thickness more than three time its diameter.

43.19.10 Bolts at the joints shall be so staggered that nuts may be tightened with spanners without fouling.

43.19.11 Fasteners of grade higher than 8.8 are not to be used.

43.20.0 Materials

The materials of the various components shall be as specified hereunder. The Bidders hall indicate the material proposed to be used for each and every component of hardware fitting stating clearly the class, grade or alloy designation of the material, manufacturing process & heat treatment details and the reference standards.

Sl. No.	Name of item	Material treatment	Process of Standard	Reference	Remarks

1	Security Clips	Stainless Steel/ Phospher Bronze	-	AISI 302 or 304-L/ IS-1385	
2	Arcing Horn	Mild Steel Rod/ Tube Type	Hot dip galvanised	As per IS-226 or IS-2062	
3	Ball Fittings, Socket, all shackles links cleves	Class-IV Steel	Drop forged & normalized Hot dip galvanised	As per IS: 2004	
4	Yoke Plate	Mild Steel	Hot dip galvanized	As per IS-226 or IS-2062	
5	Sag Adjustment plate	Mild Steel	Hot dip galvanized	As per IS-226 or IS-2062	
6(a).	Corona Control ring/ Grading ring	High Strength Al. Alloy tube (6061/ 6063/1100 type or 65032/ 63400 Type)	Heat treated Hot dip galvanized	ASTM-B429 or as per IS	Mechanical strength of welded joint shall not be less than 20 KN
6(b).	Supporting Brackets & Mounting Bolts	High Strength Al Alloy 7061/ 6063/ 65032/63400 Type) or Mild Steel	Heat treated Hot dip galvanized	ASTM-B429 or as per IS:226 or IS:2062	
7(a).	Envelope type Clamp: Clamp Body, Keeper Piece	High Strength Al. Alloy 4600/ LM-6 or 6061/65032 or 6063/63400	Casted or forged & Heat treated	IS:617 or ASTM-B429	
7(b).	Envelope type Clamp: Cotter bolts/ Hangers, Shackles, Brackets	Mild Steel	Hot dip galvanised	As per IS-226 or IS-2062	

7(c)	Envelope type Clamp: U Bolts	Stainless Steel or High Strength Al alloy 6061/ 6063 or 65032/63400	Forged & Heat treated	AISI 302 or 304-L ASTM-B429	
8(a).	Dead End Assembly: Outer Sleeve	EC grade Al of purity not less than 99.50%			
8(b).	Steel Sleeve	Mild Steel	Hot Dip Galvanised	IS:226/ IS-2062	
9.	AGS clamp (a) Supporting house	High strength corrosion resistant Al. alloy LM6, 4600 or equivalent 6061	Cast/forged heat treated.	IS:617 or equivalent	
	(b) Al insert and retaining strap	High strength Al alloy type 6061 or equivalent	Forged and Heat treated	ASTM:B429	
	(c) Elastomer cushion	Moulded on Al reinforcement			
10.	P. A. rod	High strength Al alloy type 6061 or equivalent	Heat treatment during manufacturing	ASTM:B429	Min. tensile strength of 35 kg/mm2
11.	Turn Buckle	Class-II Steel	Forged hot dip galvanized	IS:2004	

43.21.0 Workmanship

43.21.1 All the equipment shall be of the latest design and conform to the best modern practices adopted in the Extra High Voltage field. The Bidder shall offer only such equipment as guaranteed by him to be satisfactory and suitable for rated voltage of transmission lines and will give continued good performance.

43.21.2 The design, manufacturing process and quality control of all the materials shall be such as to give the specified mechanical rating, highest mobility, elimination of sharp edges and comers to limit corona and radio-interference, best resistance to corrosion and a good finish.

43.21.3 All ferrous parts including fasteners shall be hot dip galvanized, after all machining has been completed. Nuts may, however, be tapped (threaded) after galvanizing and the threads oiled. Spring washers shall be electro galvanized. The bolt threads shall be undercut to take care of the increase in diameter due to galvanizing. Galvanizing shall he done in accordance with IS: 2629 / IS-1367 (Part 13) or equivalent International Standards and shall satisfy the tests mentioned in IS: 2633-1986or equivalent International Standards. Fasteners shall withstand four dips while spring washers shall withstand three dips of one-minute duration in the standard Preece test. Other galvanized materials shall have a minimum average coating of zinc equivalent to 610 gm / sq.m shall be guaranteed to withstand at least six successive dips each lasting one (1) minute under the standard price test for galvanizing.

43.21.4 Before ball fittings are galvanized, all die flashing on the shank and on the bearing surface of the ball shall be carefully removed without reducing the dimensions below the design requirements.

43.21.5 The zinc coating shall be perfectly adherent of uniform thickness, smooth, reasonably bright. Continuous and free from imperfections such as flux, ash, rust, stains, bulky white deposits and blisters. The zinc used for galvanizing shall be grade Zn 99.95 as per IS: 209or equivalent International Standards.

43.21.6 Pin balls shall be checked with the applicable “GO” gauges in at least two directions. one of which shall be across the line of die flashing, and the other 90o to this line. "NO GO" gauges shall not pass in any direction.

43.21.7 Socket ends, before galvanizing, shall be of uniform contour. The bearing surface of socket ends shall be uniform about the entire circumference without depressions, of high spots. The internal contours of socket ends shall be concentric with the axis of the fittings as per IS: 2486or equivalent International Standards.

The axis of the bearing surfaces of socket ends shall be coaxial with the axis of the fittings. There shall be no noticeable tilting of the bearing surfaces with the axis of the fittings.

43.21.8 In case of casting, the same shall be free from all internal defects like shrinkage, inclusion, blow holes, etc. Pressure die casting shall not be used for casting of components with thickness more than 5 mm

43.21.9 All current carrying parts shall be so designed and manufactured that contact resistance is reduced to minimum.

43.21.10 No equipment shall have sharp ends or edges, abrasions or projections and cause any damage to the inductor in any way during erection or during continuous operation which would product high electrical and mechanical stresses in normal working. The design of adjacent metal parts and mating surfaces shall be such as to prevent corrosion of the contact surface and to maintain good electrical contact under service conditions.

43.21.11 All the holes shall be cylindrical, clean cut and perpendicular to the plane of the material. The periphery of the holes shall be free from burrs.

43.21.12 All fasteners shall have suitable corona free locking arrangement to guard against Vibration loosening.

43.21.13 Welding of aluminium shall be by inert gas shielded tungsten arc or inert gas shielded metal arc process. Welds shall be clean, sound, smooth, uniform without overlaps, properly fused and completely sealed. There shall be no cracks, voids incomplete penetration, incomplete fusion, under-cutting or inclusions. Porosity shall be minimised so that mechanical properties of the aluminium alloys are not affected. All welds shall be properly finished as per good engineering practices.

43.22.0 Bid Drawings

43.22.1 The Bidder shall furnish full description and illustrations of materials offered.

43.22.2 Fully dimensioned drawings of the complete insulator string hardware and their component parts showing clearly the following arrangements shall be furnished in five (5) copies along with the bid. Weight, material and fabrication details of all the components should be included in the drawings.

(i) Attachment of the hanger or strain plate.

(ii) Yoke Plate

(iii) Suspension or dead-end assembly.

(iv) Arcing horn attachment to the string

(v) Hardware fittings of ball and socket type for inter connecting units.

(iv) Corona control rings/grading ring attachment to conductor and other small accessories.

43.22.3 All drawings shall be identified by a drawing number and contract number. All drawings shall be neatly arranged. All drafting & lettering shall be legible. The minimum size of lettering shall be 3 mm. All dimensions & dimensional tolerances shall be mentioned in mm.

The drawings shall include:

(i) Dimensions and dimensional tolerance.

(ii) Material, fabrication details including any weld details & any specified finishes & coatings. Regarding material designation & reference of standards are to be indicated.

(iii) Catalogue No.

(iv) Marking

(v) Weight of assembly

(vi) Installation instructions

(vii) Design installation torque for the bolt or cap screw.

(viii) Withstand torque that may be applied to the bolt or cap screw without failure of component parts.

(ix) The compression die number with recommended compression pressure.

(x) All other relevant terminal details.

43.22.4 After placement of award, the Contractor shall submit fully dimensioned drawings including all the components in four (4) copies to the Employer for approval. After getting approval from the Employer and successful completion of all the type tests, the Contractor shall submit thirty (10) more copies of the same drawings to the Employer for further distribution and field use at Employer's end.

43.23.0 **Completeness of works**

Bidder shall assess the complete requirement of line hardware, hardware accessories and assemblies in complete for the erection of the lines as per the recommended erection practices.

The hardware assemblies shall be supplied complete with components, sub-components, nuts, bolts, washer etc. fittings and accessories for conductor & earth wire like Mid Span Joints, Repair Sleeves, and Stockbridge Vibration Dampers.

The Contractor shall also supply all line and tower accessories.

43.24.0 **Standards**

43.24.1 The Hardware Fittings, conductor and earth wire accessories shall conform to the following Indian Standards or equivalent International Standards, which shall mean latest revisions, amendments/changes adopted and published unless specifically stated otherwise in the specification.

1.	IS: 209	Specification for Zinc.
2.	IS: 398	Specification for Aluminum Conductors.
		for Overhead Transmission Purposes,
3.	IS: 1327	Method of Determination of Weight of
		Zinc Coating on Tin Plate.
4.	IS: 1573	Electroplated Coating of Zinc on Iron and Steel
5.	IS: 2121	Specification for Conductors and Earthwire
		Accessories for Overhead Power Lines
	(Part-1)	Armour Rods, Binding Wires and Tapes for
		Conductors
	(Part-2)	Mid-span joints and Repair Sleeves for
		Conductors
6.	IS : 2486	Specification for Insulator Fittings for Overhead Power Lines
		With a Nominal Voltage Greater than 1 000 V
	(Part 1)	General Requirements and Tests
7.	IS:2629	Recommended Practice for Hot Dip
		Galvanizing of Iron and Steel
8.	IS:2633	Method of Testing Uniformity of Coating
		on Zinc Coated Articles
9.	IS:4826	Galvanized Coating on Round Steel Wires

10. IS : 6639 Hexagonal Bolts for Steel Structures

11. IS: 6745 Methods for Determination of Weight of Zinc Coating on Zinc Coated Iron and Steel Articles

12. IS : 8263 Method for Radio Interference Tests on High Voltage Insulators

13. IS : 9708 Specification for Stock Bridge vibration Dampers for Overhead Power Lines

43.25.0 TESTS

The insulator discs and hardware fittings shall be subjected to the tests before despatch, in accordance with the relevant standards. The successful contractor shall submit the test results in quadruplicate to the Employer.

43.26.0 MARKING

Each insulator disc shall be legibly and indelibly marked with the following:

- Name or trade mark of the manufacturer.
- Month and year of manufacture.
- Minimum failing load in Newton.
- Country of manufacture
- Standard certification mark, if any.

The marking of the porcelain shall be printed and shall be applied before firing.

43.27.0 STANDARDIZED TECHNICAL PARAMETERS

A) Standardized Technical Particulars of Hardware Fittings for 400 kV Transmission Line with Quad ACSR MOOSE Conductor

1.	**Suspension hardware fittings for Quad ACSR MOOSE conductor**				
Sl.	**Description**	**Unit**	**Particulars / Value**		
			Double 'I' / Double 'I' (RC)#		**Single 'I' Pilot**
			AGS clamp	**Free centre clamp**	**Envelope clamp**
1.	Maximum magnetic power loss of suspension assembly at sub conductor current of 600 amperes, 50Hz AC	Watt	4		8

2.	Slipping strength of suspension assembly(clamp torque Vs slip curve shall be enclosed)	kN	20-29		
3.	Particulars of standard/AGS Standard / AGS preformed armour rod set for suspension assembly				
	a) No. of rods per set	No.	12		NA
	b) Direction of lay		Right Hand		NA
	c) Overall length after fitting on conductor	mm	2235	2540	NA
	d) Diameter of each rod	mm	9.27		NA
	e) Tolerance in				NA
	i) Diameter of each rod	±mm	0.10		NA
	ii) Length of each rod	±mm	25		NA
	iii) Difference of length between the longest and shortest rod in a set	±mm	13		NA
	g) Type of Aluminium alloy used for manufacture of PA rod set		6061/ 65032		NA
	h) UTS of each rod	Kg/mm^2 (Min)	35		NA
4.	**Particulars of Elastomer (For AGS Clamp only)**				
	a) Type of elastomer		Chloroprene / Neoprene	NA	NA
	b) Shore hardness of elastomer		65 - 80	NA	NA
	c) Temperature range for which elastomer is designed	°C	Upto 95°C	NA	NA
	d) Moulded on insert		Yes	NA	NA
5.	Mechanical Strength of Suspension fitting (excluding suspension clamp)	KN	Double I :240 Double 'I' (RC): 640		120
6.	Mechanical Strength of suspension clamp.		70	70	70
7.	Purity of Zinc used for galvanising	%	As per IS:209 / IS 13229		
8.	Min. No. of dips in standard preece test the ferrous parts can withstand	No	a) Fasteners : 4 dips of 1 min b) Spring washers : 3 dips of 1 min c) All others : 6 dips of 1 min		

2.	Tension hardware fittings for Quad ACSR MOOSE conductor				
Sl.	**Description**	**Unit**	**Particulars / Value**		
			Single Tension	**Quad Tension**	**Quad Tension # (RC)**
1.	Mechanical Strength of Tension fittings (excluding dead end clamp)	kN	120	640	920
2.	Type of Dead End assembly		Compression		
3.	Compression Pressure	MT	100		
4.	Maximum electrical resistance of dead end assembly as a percentage of equivalent length of Conductor	%	75		
5.	Slip strength of dead end assembly	kN	153.2		214
6.	Purity of Zinc used for galvanising	%	As per IS:209 / IS 13229		
7.	Min. No. of dips in standard preece test the ferrous parts can withstand.	Nos	a) Fasteners : 4 dips of 1 min b) Spring washers : 3 dips of 1 min c) All others : 6 dips of 1 min		

#: To be used with AACSR MOOSE Conductor

B) Standardized Technical Particulars of Hardware Fittings for 400 kV Transmission Line with twin ACSR MOOSE Conductor

1.	Suspension hardware fittings for twin ACSR MOOSE* conductor						
Sl.	**Description**	**Unit**	**Particulars/ Value**				
			Single "I" Suspension Fittings with		**Double "V" Suspension Fittings with** *(AACSR MOOSE Conductor)*		**Single suspension Pilot Fitting with**
			AGS clamp	**Free Centre clamp**	**AGS clamp**	**Free Centre clamp**	**Envelope clamp**
1.	Maximum magnetic power loss of one suspension assembly at sub-conductor current of 600 amperes	Watt	4		4		8
2.	Slipping strength of suspension assembly	KN	20-29		20-29		20-29
3.	Particulars of standard/ AGS						

	preformed armour rod set for suspension assembly						
	a) No. of rods per set	No.	12		12		NA
	b) Direction of lay		Right hand		Right hand		NA
	c) Overall length after fitting on conductor	mm	2235	2540	2235	2540	NA
	d) Diameter of each rod	mm	9.27		9.27		NA
	e) Tolerance in						
	i) Diameter of each rod	±mm	0.10		0.10		NA
	ii) Length of each rod	±mm	25		25		NA
	iii) Difference of length between the longest and shortest rod in a set	±mm	13		13		NA
	f) Type of Aluminium alloy used for manufacture of PA rod set		6061/ 65032		6061/ 65032		NA
	g) Minimum UTS of each rod	Kg/mm^2	35		35		NA
4.	**Particulars of Elastomer (For AGS Clamp only)**						
	a) Type of elastomer		Chloroprene/Neoprene Rubber	NA	Chloroprene /Neoprene Rubber	NA	NA
	b) Shore hardness of elastomer		65 to 80	NA	65 to 80	NA	NA
	c) Temperature range for which elastomer is designed		Upto 95^o C	NA	Upto 95^o C	NA	NA
	d) Moulded on insert		Yes	NA	Yes	NA	NA
5.	Mechanical strength of suspension fitting(excluding suspension clamp)	KN	120		2 x160 (along one limb)		120
6.	Mechanical strength of suspension clamp	KN	70		120		70
7.	Galvanising						
a)	Minimum weight of Zinc coating for steel parts	gm/m2	600				
b)	Purity of Zinc used for galvanising	%	99.95 (IS 209) or 98.5 (IS 13229)				

c)	Min. No. of dips in standard preece test the ferrous parts can withstand	No.	a) Fasteners: 4 dips of 1 minute b) Spring washers: 3 dips of 1 minute c) all others: 6 dips of 1 minute

** : except Double 'V' Suspension and Triple Tension fittings*

1.	**Tension hardware fittings for twin ACSR MOOSE* conductor**				
Sl.	**Description**	**Unit**	**Particulars/ Value**		
			Single Tension	**Double Tension**	**Triple Tension** ***(AACSR MOOSE Conductor)***
1.	Mechanical strength of Tension fitting(excluding dead end clamp)	KN	120	2x160	3x160
2.	Type of dead end assembly		Compression		
3.	Compression pressure	MT	100		
4.	Maximum electrical resistance of dead end assembly as a percentage of equivalent length of Conductor	%	75		
5.	Slip strength of dead end assembly	KN	153.2		214 (AACSR 'MOOSE' to be used)
6.	Galvanising				
a)	Minimum weight of Zinc coating for steel parts	gm/m2	600		
b)	Purity of Zinc used for galvanising	%	99.95 (IS 209) or 98.5(IS 13229)		
c)	Min. No. of dips in standard preece test the ferrous parts can withstand.	Nos.	a) Fasteners: 4 dips of 1 minute b) Spring washers: 3 dips of 1 minute c) all others: 6 dips of 1 minute		

** : except Double 'V' Suspension and Triple Tension fittings*

C) Accessories for ACSR MOOSE conductor for 400 kV transmission line

Mid span compression Joint for ACSR MOOSE Conductor			
Sl.	**Description**	**Unit**	**Particulars/ Value**

			Aluminium Sleeve	Steel Sleeve
1.	**Material of Joint**		Aluminium of purity 99.5%	Mild Steel(Fe-410, IS:2062)
2.	Range of Hardness of the steel sleeve (Brinnel hardness)	BHN	From 100 to 200	
3.	Weight of Zinc coating for steel sleeve	gm/m^2	610	
4.	**Dimension of sleeve Before compression**		Aluminum sleeve	Steel sleeve
i)	Inside diameter	mm	34.00 ± 0.5	11.50 ± 0.2
ii)	Outside diameter	mm	54.00 ± 1.0	21.00 ± 0.5
iii)	Length	mm	735 ± 5	250 ± 5
5.	**Dimensions of Sleeve after compression**		Aluminum sleeve	Steel sleeve
i)	Outside dimension(Corner to corner)	mm	53.00 ± 0.5	20.20 ± 0.5
ii)	Outside dimension (face to face)	mm	46.00 ± 0.5	17.50 ± 0.5
iii)	Length	mm	785 (approx)	286 (approx)
5.	Slip strength	KN	153.2	
6.	Maximum resistance of the compressed unit expressed, as percentage of the resistance of equivalent length of bare conductor.	%	75	
7.	Minimum corona Extinction voltage kV (rms) under dry condition	kV	320	
8.	Maximum Radio Interference Voltage at 1 MHz for phase to earth voltage of 305 kV (rms) under dry condition	Micro Volts	1000	

Repair sleeve for ACSR MOOSE Conductor			
Sl.	**Description**	**Unit**	**Particulars/ Value**
1.	**Material**		Aluminium of min purity 99.5%

2.	**Dimension of Aluminum sleeve Before compression**		
i)	Inside diameter	mm	34.00 ± 0.5
ii)	Outside diameter	mm	54.00 ± 1.0
iii)	Length	mm	300.00 ± 5.0
3.	**Dimensions of Aluminum Sleeve after compression**		
i)	Outside dimension(Corner to corner)	mm	53.00 ± 0.5
ii)	Outside dimension (face to face)	mm	46.00 ± 0.5
iii)	Length	mm	330.00(Approx.)
4.	Minimum corona Extinction voltage kV (rms) under dry condition	kV	320
5.	Maximum Radio Interference Voltage at 1 MHz for phase to earth voltage of 305 kV (rms) under dry condition	Micro Volts	1000

T-connector for ACSR MOOSE Conductor			
Sl.	**Description**	**Unit**	**Particulars/ Value**
1.	**Material**		Aluminium of purity 99.5%
2.	**Dimension of Aluminum sleeve Before compression**		
	i) Inside diameter	mm	34.00 ± 0.5
	ii) Outside diameter	mm	54.00 ± 1.0
	iii) Length	mm	400.00 ± 5.0
3.	**Dimensions of Aluminum Sleeve after compression**		
	i) Outside dimension(Corner to corner)	mm	53.00 ± 0.5
	ii) Outside dimension (face to face)	mm	46.00 ± 0.5
4.	Axial tensile strength of welded portion of T-connector	KN	30
5.	Maximum resistance of the compressed unit expressed, as percentage of the resistance of equivalent length of bare conductor.	%	75
6.	Minimum corona Extinction voltage kV (rms) under dry condition	kV	320
7.	Maximum Radio Interference Voltage at 1 MHz for phase to earth voltage of 305 kV (rms) under dry condition	Micro Volts	1000

Vibration Damper for ACSR MOOSE conductor (For twin bundle conductor line only)			
Sl.	**Description**	**Unit**	**Particulars/ Value**
1.	Type of Damper		4R-Stockbridge type
2.	Materials of components		
	a) Damper masses		Cast iron/mild steel/Zinc alloy duly hot dip galvanised
	b) Clamp		Aluminum alloy 4600
	c) Messenger cable		High tensile strength galvanized steel
3.	Number of strands in stranded messenger cable	Nos.	19
4.	Minimum ultimate tensile strength of stranded messenger cable	Kg/m m^2	135
5.	Slip strength of stranded messenger cable (mass pull off)	KN	5
6.	Slipping strength of damper clamp		
	(a) Before fatigue test	KN	2.5
	(b) After fatigue test	KN	2
7.	Resonance frequencies range	Hz	5 to 40
8.	Maximum magnetic power loss per vibration damper watts for 600 amps, 50 Hz Alternating Current	Watts	1
9.	Minimum corona Extinction voltage kV (rms) under dry condition	kV	320
10.	Maximum Radio Interference Voltage (RIV) at 1 MHz for phase to earth voltage of 305 kV (rms) under dry condition	Micro Volts	1000
11.	Percentage variation in reactance after fatigue test in comparison with that . before fatigue test	%	+/-40 (Maximum)
12.	Percentage variation in power dissipation after fatigue test in comparison with that before fatigue test	%	+/-40 (Maximum)
13.	Galvanising		
a)	Minimum weight of Zinc coating for steel	gm/m2	600

	parts		
b)	Purity of Zinc used for galvanising	%	99.95 (IS 209) or 98.5(IS 13229)
c)	Min. No. of dips in standard preece test the ferrous parts can withstand.	Nos.	a) Fasteners: 4 dips of 1 minute b) Spring washers: 3 dips of 1 minute c) all others: 6 dips of 1 minute

Bundle Spacer for ACSR MOOSE conductor (For twin bundle conductor line only)					
Sl.	**Description**	**Unit**	**Particulars/ Value**		
1.	Type of Bundle Spacer		Armour grip type		
2.			**Insert**	**Main body**	**Retaining rods (if any)**
(i)	Materials of components		Aluminum alloy 6061/65032	Tube Aluminum alloy 6063/63400; 6061/65032	Aluminum alloy 6061/65032
(ii)	Manufacturing process of component parts		Forged	Tube-extrusion	Heat treatment during manufacturing
3.	**Retaining rods (if used)**				
	(a) Number of retaining rods used for each spacer	no.	8		
	(b) Diameter	mm	7.87 ± 0.1		
	(c) Length	mm	1100+15		
	(d) Minimum UTS of rods	Kg/mm^2	35		
4.	**Elastomer**				
	(a) Type		Chloroprene/Neoprene		
	(c) Moulded on insert		Yes		
	(d) Shore hardness		65 to 80		

	(e) Thickness on insert	mm	5(Average)
	(f) Temp. range for which designed	°C	95
5.	**Minimum ultimate tensile strength of spacer**		
	(a) Compressive load	kN	14
	(b) Tensile load	kN	7
6.	Slipping strength of spacer clamp		
	a) Before vibration test	KN	2.5
	b) After vibration test	KN	2
7.	Minimum corona Extinction voltage kV (rms) under dry condition	kV	320
8.	Maximum Radio Interference Voltage (RIV) at 1 MHz for phase to earth voltage of 305 kV (rms) under dry condition	Micro volts	1000

Rigid Spacer for Jumper for ACSR MOOSE conductor (For twin bundle conductor line only)			
Sl.	**Description**	**Unit**	**Particulars/ Value**
1.	Type of Spacer		Rigid type without retaining rods
2.	**Material of component parts**		
	(a) Clamp		Aluminum alloy (4600)
	(b) Main body		Aluminum alloy 6063/63400 ; **6061/65032**
3.	**Manufacturing process of component parts**		
	(a) Clamp		Die-casting
	(b) Main body		Aluminum extrusion
4.	**Minimum ultimate tensile strength of spacer**		
	(a) Compressive load	kN	14
	(b) Tensile load	kN	7.0
5.	Slipping strength of spacer clamp	kN	2.5
6.	Maximum Magnetic power loss per spacer for 600 Amps, 50 Hz Alternating Current	Watts	1

7.	Minimum corona Extinction voltage kV (rms) under dry condition	kV	320
8.	Maximum Radio Interference Voltage (RIV) at 1 MHz for phase to earth voltage of 305 kV (rms) under dry condition	Micro volts	1000

Quad Rigid Spacer for Jumper for ACSR MOOSE conductor (For quadruple bundle conductor line only)					
Sl.	**Description**	**Unit**	**Particulars / Value**		
1.	Material of				
	(a) Clamp		Al Alloy IS:4600 or Equivalent		
	(b) Body		Galvanised Steel / Al Alloy 4600 or Equivalent		
2.	Elastomer (*if used*)				
	(a) Shore hardness		65 - 80		
	(b) Temp. range for which designed	°C	Upto 95°C		
3.	Minimum ultimate tensile strength of spacer				
	(a) Compressive load	kN	14		
	(b) Tensile load	kN	7.0		
4.	Slipping strength of spacer clamp	kN	**Clamp type**	**Longitudnal Load (kN)**	**Maxm Slip permitted (mm)**
			Metal – Metal Bolted	6.5	1
			Rubber loaded	2.5	2.5
			Preformed rod	2.5	12
5.	Maximum magnetic power loss of at sub conductor current of 600 amperes, 50Hz AC	Watts	Below 1 watt.		
6.	Minimum corona Extinction voltage kV (rms) under dry condition	kV	320		

7.	Radio Interference Voltage at 1 MHz for phase to earth voltage of 305 kV (rms) Microvolts under dry condition	µV	Below 1000

Spacer damper for Quad ACSR MOOSE conductor

Sl.	**Description**	**Unit**	**Particulars / Value**
1.	Type of Clamps		Preformed rods.
2.	Type of Damping element		Spring / Elastomer / EPDM
3.	Material of		
	(a) Clamp		Al Alloy IS:4600 or Equivalent for Casting & Al Alloy 6061 or Equivalent (for Forging)
	(b) Body		
4.	Elastomer (*if used*)		
	(a) Shore hardness		50 - 80
	(b) Temp. range for which designed	°C	Upto 95°C
5.	Minimum ultimate tensile strength of spacer		
	(a) Compressive load	kN	14
	(b) Tensile load	kN	7.0
6.	Slipping strength of spacer clamp		
	(a) Before vibration test	kN	**Clamp type** | **Longitudnal Load (kN)** | **Maxm Slip permitted (mm)** Preformed rods | 2.5 | 12
	(b) After vibration test	kN	80% of the above values
7.	Minimum corona Extinction voltage kV (rms) under dry condition	kV	320
8.	Radio Interference Voltage at 1 MHz for phase to earth voltage of 305 kV (rms) Microvolts under dry condition	µV	Below 1000

C) Accessories for 7/3.66 mm GS Earthwire for 400 Kv/765 Kv transmission line

Mid span compression Joint for 7/3.66 mm GS Earthwire

Sl.	Description	Unit	Particulars/ Value		
			Aluminium / Filler Sleeve	Steel Sleeve	
1.	**Material of Joint**		Aluminium of minimum purity 99.5%	Mild Steel(Fe-410, IS:2062)	
2.	Range of Hardness of the steel sleeve (Brinnel hardness)	BHN	From 100 to 200		
3.	Weight of Zinc coating	gm/m^2	600		
4.	**Dimension of sleeve Before compression**				
			Aluminium Sleeve	Steel Sleeve	Alu filler sleeve
i)	Inside diameter	mm	22.00 ± 0.5	11.50 ± 0.2	11.50 ± 0.2
ii)	Outside diameter	mm	32.00 ± 0.5	21.00 ± 0.5	21.00 ± 0.5
iii)	Length	mm	400 ± 5	230 ± 5	60 ± 5
5.	**Dimensions of Sleeve after compression**				
			Aluminium Sleeve	Steel Sleeve	
i)	Outside dimension(Corner to Corner)	mm	29.40 ± 0.5	20.20 ± 0.5	
ii)	Outside dimension (face to face)	mm	25.00 ± 0.5	17.50 ± 0.5	
iii)	Length	mm	430 (approx)	265 (approx)	
6.	Slip strength	KN	65		
7.	Maximum resistance of the compressed unit expressed, as percentage of the resistance of equivalent length of bare Earthwire	%	75		

Flexible Aluminium Bond for 7/3.66 mm GS Earthwire

Sl.	Description	Unit	Particulars/ Value
1.	Stranding		19 (12+6+1) / dia 2.54
2.	Cross sectional area	Sq.mm	95

4.	Length of aluminium cable	mm	750 + 5
5.	Material of lugs		Aluminium alloy
6.	Bolt Size		
	i) Diameter	mm	16
	ii) Length	mm	40

Vibration Damper for 7/3.66 mm GS Earthwire

Sl.	Description	Unit	Particulars/ Value
1.	Type of Damper		4R-Stockbridge type
2.	Materials of components		
	a) Damper masses		Cast iron/mild steel/Zinc alloy duly hop dip galvanised
	b) Clamp		Aluminum alloy 4600
	c) Messenger cable		High tensile strength galvanized steel
3.	Number of strands in stranded messenger cable	Nos.	19
4.	Minimum ultimate tensile strength of stranded messenger cable	Kg/mm^2	135
5.	Slip strength of stranded messenger cable (mass pull off)	kN	2.5
6.	Slipping strength of damper clamp		
	(a) Before fatigue test	kN	2.5
	(b) After fatigue test	kN	2
7.	Resonance frequencies range	Hz	10 to 60
8.	Percentage variation in reactance after fatigue test in comparison with that . before fatigue test	%	+/-40 (Maximum)
9.	Percentage variation in power dissipation after fatigue test in comparison with that before fatigue test	%	+/-40 (Maximum)

Suspension Clamp for 7/3.66 mm GS Earthwire

Sl.	Description	Unit	Particulars/ Value

1.	**Material of components**		
	(a) Shackle		Forged Steel
	(b) Clamp Body & Keeper		Malleable cast iron / SGI
	(c) U- Bolt		Mild Steel
2.	Total Drop (Maximum)	mm	150
3.	Breaking Strength (Minimum)	kN	25
4.	Slipping Strength	kN	12 to 17
5.	Galvanising		
a)	Minimum weight of Zinc coating for steel parts	gm/m^2	600
b)	Purity of Zinc used for galvanising	%	99.95 (IS 209) or 98.5 (IS 13229)
c)	Min. No. of dips in standard preece test the ferrous parts can withstand (wherever applicable)	No.	a) Fasteners: 4 dips of 1 minute b) Spring washers: 3 dips of 1 minute & c) all others: 6 dips of 1 minute

Tension Clamp for 7/3.66 mm GS Earthwire

Sl.	Description	Unit	Particulars/ Value		
1.	**Material of components**				
	(i) Anchor Shackle		Forged Steel		
	(ii) Compression Clamp				
	a) Steel Sleeve		Mild Steel		
	b) Aluminium sleeve		Aluminium of purity 99.5%		
	c) Aluminium Filler sleeve		Aluminium of purity 99.5%		
2.	Range of Hardness of the steel sleeve (Brinnel hardness)	BHN	120-200		
3.	**Dimension of sleeve Before compression**				
			Aluminium Sleeve	Steel Sleeve	Alu filler sleeve
i)	Inside diameter	mm	22.00 ± 0.5	11.50 ± 0.2	11.50 ± 0.2
ii)	Outside diameter	mm	30.00 ±	21.00 ± 0.5	21.00 ±

			0.5		0.5
iii)	Length	mm	245 ± 5	205 ± 5	25 .0
4.	**Dimensions of Sleeve after compression**				
			Aluminium Sleeve	Steel Sleeve	
i)	Outside dimension(Corner to Corner)	mm	29.40 ± 0.5	20.20 ± 0.5	
ii)	Outside dimension (face to face)	mm	25.00 ± 0.5	17.50 ± 0.5	
5.	Slip strength	KN	65		
6.	Minimum Breaking strength of assembly (excluding clamp)	KN	70		
7.	Compression Pressure	Ton	100		
8.	Galvanising				
a)	Minimum weight of Zinc coating for steel parts	gm/m^2	600		
b)	Purity of Zinc used for galvanising	%	99.95 (IS 209) or 98.5 (IS 13229)		
c)	Min. No. of dips in standard preece test the ferrous parts can withstand (wherever applicable)	No.	a) Fasteners: 4 dips of 1 minute b) Spring washers: 3 dips of 1 minute & c) all others: 6 dips of 1 minute		

D) 220 kV Transmission Line with ACSR ZEBRA conductor

1. Suspension hardware fittings for ACSR ZEBRA Conductor

Sl.	**Description**	**Unit**	**Particulars/ Value**				
			Single "I" Suspension Fittings with		**Double "I" Suspension Fittings with**		**Single suspension Pilot Fitting with**
			AGS clamp	**Free Centre clamp**	**AGS clamp**	**Free Centre clamp**	**Envelope clamp**
1.	Maximum magnetic power loss of one suspension assembly at sub-conductor current of 500 amperes	Watt	2	2	2	2	4
2.	Slipping strength of suspension	KN	16-24	16-24	16-24	16-24	16-24

	assembly						
3.	Particulars of standard/ AGS preformed armour rod set for suspension assembly						
	a) No. of rods per set	No.	12	12	12	12	NA
	b) Direction of lay		Right hand	Righ t hand	Right hand	Right hand	NA
	c) Overall length after fitting on conductor	mm	2080	2540	2080	2540	NA
	d) Diameter of each rod	mm	7.87	7.87	7.87	7.87	NA
	e) Tolerance in						
	i) Diameter of each rod	±mm	0.10	0.10	0.10	0.10	NA
	ii) Length of each rod	±mm	25	25	25	25	NA
	iii) Difference of length between the longest and shortest rod in a set	±mm	13	13	13	13	NA
	f) Type of Aluminium alloy used for manufacture of PA rod set		6061/ 65032	6061/ 65032	6061/ 65032	6061/ 65032	NA
	g) Minimum UTS of each rod	Kg/mm^2	35	35	35	35	NA
4.	**Particulars of Elastomer (For AGS Clamp only)**						
	a) Type of elastomer		Chloro prene/ Neo prene Rubbe r	NA	Chloro prene /Neo prene Rubbe r	NA	NA
	b) Shore hardness of elastomer		65 to 80	NA	65 to 80	NA	NA
	c) Temperature range for which elastomer is designed		Upto 95^o C	NA	Upto 95^o C	NA	NA
	d) Moulded on insert		Yes	NA	Yes	NA	NA
5.	Mechanical strength of suspension fitting(excluding suspension clamp)	KN	70		2 x 70		70
6.	Mechanical strength of suspension clamp	KN	70		70		70

7.	Galvanising		
a)	Weight of Zinc coating for steel parts	gm/m^2	600
b)	Purity of Zinc used for galvanising	%	99.95 (IS 209: 1992) or 98.5 (IS 13229:1991)
c)	Min. No. of dips in standard preece test the ferrous parts can withstand (wherever applicable)	No.	a) Fasteners: 4 dips of 1 minute b) Spring washers: 3 dips of 1 minute & c) all others: 6 dips of 1 minute

2. Tension hardware fittings for ACSR ZEBRA Conductor

Sl.	Description	Unit	Particulars/ Value	
			Single Tension	**Double Tension**
1.	Mechanical strength of Tension fitting(excluding dead end clamp)	KN	120	2x120
2.	Type of dead end assembly		Compression	
3.	Compression pressure	MT	100	
4.	Maximum electrical resistance of dead end assembly as a percentage of equivalent length of Conductor	%	75	
5.	Slip strength of dead end assembly	KN	123.80	
6.	Galvanising			
a)	Minimum weight of Zinc coating for steel parts	gm/m^2	600	
b)	Purity of Zinc used for galvanising	%	99.95 (IS 209) or 98.5 (IS 13229)	
c)	Min. No. of dips in standard preece test the ferrous parts can withstand (wherever applicable)	No.	a) Fasteners: 4 dips of 1 minute b) Spring washers: 3 dips of 1 minute & c) all others: 6 dips of 1 minute	

E. Accessories for ACSR ZEBRA conductor for 220 kV transmission line

1. Mid span compression Joint for ACSR ZEBRA Conductor

Sl.	Description	Unit	Particulars/ Value

			Aluminium Sleeve	Steel Sleeve
1.	**Material of Joint**		Aluminium of minimum purity 99.5%	Mild Steel(Fe-410, IS:2062)
2.	Range of Hardness of the steel sleeve (Brinnel hardness)	BHN	From 100 to 200	
3.	**Dimension of sleeve Before compression**		Aluminum sleeve	Steel sleeve
i)	Inside diameter	mm	31.00 ± 0.5	10.00 ± 0.2
ii)	Outside diameter	mm	48.00 ± 1.0	20.00 ± 0.5
iii)	Length	mm	710 ± 5	241 ± 5
4.	**Dimensions of Sleeve after compression**		Aluminum sleeve	Steel sleeve
i)	Outside dimension(Corner to corner)	mm	47.00 ± 0.5	19.00 ± 0.5
ii)	Outside dimension (face to face)	mm	41.00 ± 0.5	16.00 ± 0.5
5.	Slip strength	KN	123.8	
6.	Maximum resistance of the compressed unit expressed, as percentage of the resistance of equivalent length of bare conductor.	%	75	
7.	Minimum corona Extinction voltage kV (rms) under dry condition	kV	154	
8.	Maximum Radio Interference Voltage at 1 MHz for phase to earth voltage of 154 kV (rms) under dry condition	Micro Volts	1000	
9.	Galvanising			
a)	Minimum weight of Zinc coating for steel parts	gm/m^2	600	
b)	Purity of Zinc used for galvanising	%	99.95 (IS 209) or 98.5 (IS 13229)	

c)	Min. No. of dips in standard preece test the ferrous parts can withstand (wherever applicable)	No.	a) Fasteners: 4 dips of 1 minute b) Spring washers: 3 dips of 1 minute & c) all others: 6 dips of 1 minute

2. Repair sleeve for ACSR ZEBRA Conductor

Sl.	**Description**	**Unit**	**Particulars/ Value**
1.	**Material**		Aluminium of minimum purity 99.5%
2.	**Dimension of Aluminum sleeve Before compression**		
i)	Inside diameter	mm	31.00 ± 0.5
ii)	Outside diameter	mm	48.00 ± 1.0
iii)	Length	mm	275.00 ± 5.0
3.	**Dimensions of Aluminum Sleeve after compression**		
i)	Outside dimension(Corner to corner)	mm	47.00 ± 0.5
ii)	Outside dimension (face to face)	mm	41.00 ± 0.5
4.	Minimum corona Extinction voltage kV (rms) under dry condition	kV	154
5.	Maximum Radio Interference Voltage at 1 MHz for phase to earth voltage of 154 kV (rms) under dry condition	Micro Volts	1000

3. Vibration Damper for ACSR ZEBRA Conductor

Sl.	**Description**	**Unit**	**Particulars/ Value**
1.	Type of Damper		4R-Stockbridge type
2.	Materials of components		
	a) Damper masses		Cast iron/ mild steel hot dip galvanised / Zinc alloy
	b) Clamp		Aluminum alloy 4600
	c) Messenger cable		High tensile strength galvanized steel
3.	Number of strands in stranded messenger cable	Nos.	19
4.	Minimum ultimate tensile	Kg/mm^2	135

	strength of stranded messenger cable		
5.	Slip strength of stranded messenger cable (mass pull off)	KN	5
6.	Slipping strength of damper clamp		
	(a) Before fatigue test	KN	2.5
	(b) After fatigue test	KN	2
7.	Resonance frequencies range	Hz	5 to 45
8.	Maximum magnetic power loss per vibration damper watts for 500 amps, 50 Hz Alternating Current	Watts	1
9.	Minimum corona Extinction voltage kV (rms) under dry condition	kV	154
10.	Maximum Radio Interference Voltage (RIV) at 1 MHz for phase to earth voltage of 154 kV (rms) under dry condition	Micro Volts	1000
11.	Percentage variation in reactance after fatigue test in comparison with that . before fatigue test	%	+/-40 (Maximum)
12.	Percentage variation in power dissipation after fatigue test in comparison with that before fatigue test	%	+/-40 (Maximum)
13.	Galvanising		
a)	Minimum weight of Zinc coating for steel parts	gm/m^2	600
b)	Purity of Zinc used for galvanising	%	99.95 (IS 209) or 98.5 (IS 13229)
c)	Min. No. of dips in standard preece test the ferrous parts can withstand (wherever applicable)	No.	a) Fasteners: 4 dips of 1 minute b) Spring washers: 3 dips of 1 minute & c) all others: 6 dips of 1 minute

F. **Accessories for 7/3.15 mm GS Earthwire for 220 kV and 132 kV transmission line**

1. Mid span compression Joint for 7/3.15 mm GS Earthwire

Sl.	Description	Unit	Particulars/ Value		
			Aluminium / Filler Sleeve	Steel Sleeve	
1.	**Material of Joint**		Aluminium of minimum purity 99.5%	Mild Steel(Fe-410, IS:2062)	
2.	Range of Hardness of the steel sleeve (Brinnel hardness)	BHN	From 100 to 200		
3.	**Dimension of sleeve Before compression**				
			Aluminium Sleeve	Steel Sleeve	Alu filler sleeve
i)	Inside diameter	mm	22.00 ± 0.5	10.00 ± 0.2	11.50 ± 0.2
ii)	Outside diameter	mm	30.00 ± 0.5	21.00 ± 0.5	21.00 ± 0.5
iii)	Length	mm	315 ± 5	230 ± 5	25 ± 2
4.	**Dimensions of Sleeve after compression**				
			Aluminium Sleeve	Steel Sleeve	
i)	Outside dimension(Corner to Corner)	mm	29.40 ± 0.5	20.20 ± 0.5	
ii)	Outside dimension (face to face)	mm	25.00 ± 0.5	17.50 ± 0.5	
5.	Slip strength	KN	53.20		
6.	Maximum resistance of the compressed unit expressed, as percentage of the resistance of equivalent length of bare Earthwire	%	75		
7.	Galvanising				
a)	Minimum weight of Zinc coating for steel parts	gm/m^2	600		
b)	Purity of Zinc used for	%	99.95 (IS 209) or 98.5 (IS 13229)		

	galvanising		
c)	Min. No. of dips in standard preece test the ferrous parts can withstand (wherever applicable)	No.	a) Fasteners: 4 dips of 1 minute b) Spring washers: 3 dips of 1 minute & c) all others: 6 dips of 1 minute

2. Flexible Copper Bond for 7/3.15 mm GS Earthwire

Sl.	Description	Unit	Particulars/ Value
1.	Stranding		19 (12+6+1) / dia 2.54
2.	Cross sectional area	Sq.mm	95
3.	Minimum copper equivalent area	Sq.mm	750 + 5
4.	Length of copper cable	mm	Aluminium alloy
5.	Material of lugs		19 (12+6+1) / dia 2.54
6.	Bolt Size		
	i) Diameter	mm	16
	ii) Length	mm	40

3. Vibration Damper for 7/3.15 mm GS Earthwire

Sl.	Description	Unit	Particulars/ Value
1.	Type of Damper		4R-Stockbridge type
2.	Materials of components		
	a) Damper masses		Cast iron/ mild steel hot dip galvanised / Zinc alloy
	b) Clamp		Aluminum alloy 4600
	c) Messenger cable		High tensile strength galvanized steel
3.	Number of strands in stranded messenger cable	Nos.	19
4.	Minimum ultimate tensile strength of stranded messenger cable	Kg/mm^2	135
5.	Slip strength of stranded messenger cable (mass pull off)	kN	2.5

6.	Slipping strength of damper clamp		
	(a) Before fatigue test	kN	2.5
	(b) After fatigue test	kN	2
7.	Resonance frequencies range	Hz	10 to 60
8.	Percentage variation in reactance after fatigue test in comparison with that . before fatigue test	%	+/-40 (Maximum)
9.	Percentage variation in power dissipation after fatigue test in comparison with that before fatigue test	%	+/-40 (Maximum)
10.	Galvanising		
a)	Minimum weight of Zinc coating for steel parts	gm/m^2	600
b)	Purity of Zinc used for galvanising	%	99.95 (IS 209) or 98.5 (IS 13229)
c)	Min. No. of dips in standard preece test the ferrous parts can withstand (wherever applicable)	No.	a) Fasteners: 4 dips of 1 minute b) Spring washers: 3 dips of 1 minute & c) all others: 6 dips of 1 minute

4. Suspension Clamp for 7/3.15 mm GS Earthwire

Sl.	Description	Unit	Particulars/ Value
1.	**Material of components**		
	(a) Shackle		Forged Steel
	(b) Clamp Body & Keeper		Malleable cast iron / SGI
	(c) U- Bolt		Mild Steel (Fe 410, IS 2062)
2.	Total Drop (Maximum)	mm	150
3.	Breaking Strength (Minimum)	kN	25
4.	Slipping Strength	kN	9 to 14
5.	Galvanising		
a)	Minimum weight of Zinc coating for steel parts	gm/m^2	600
b)	Purity of Zinc used for galvanising	%	99.95 (IS 209) or 98.5 (IS 13229)

c)	Min. No. of dips in standard preece test the ferrous parts can withstand (wherever applicable)	No.	a) Fasteners: 4 dips of 1 minute b) Spring washers: 3 dips of 1 minute & c) all others: 6 dips of 1 minute

5. Tension Clamp for 7/3.15 mm GS Earthwire

Sl.	Description	Unit	Particulars/ Value		
1.	**Material of components**				
	(i) Anchor Shackle		Forged Steel		
	(ii) Compression Clamp				
	a) Steel Sleeve		Mild Steel (Fe 410, IS 2062)		
	b) Aluminium sleeve		Aluminium of purity 99.5%		
	c) Aluminium Filler sleeve		Aluminium of purity 99.5%		
2.	Range of Hardness of the steel sleeve (Brinnel hardness)	BHN	100-200		
3.	**Dimension of sleeve Before compression**				
			Aluminium Sleeve	Steel Sleeve	Alu filler sleeve
i)	Inside diameter	mm	22.00 ± 0.5	10.00 ± 0.2	11.50 ± 0.2
ii)	Outside diameter	mm	30.00 ± 0.5	21.00 ± 0.5	21.00 ± 0.5
iii)	Length	mm	220 ± 5	180 ± 5	25 .0±2
4.	**Dimensions of Sleeve after compression**				
			Aluminium Sleeve	Steel Sleeve	
i)	Outside dimension(Corner to Corner)	mm	29.40 ± 0.5	20.20 ± 0.5	
ii)	Outside dimension (face to face)	mm	25.00 ± 0.5	17.50 ± 0.5	
5.	Slip strength	KN	53.20		
6.	Minimum Breaking strength of assembly (excluding clamp)	KN	70		
7.	Compression Pressure	Ton	100		
8.	Galvanising				

a)	Minimum weight of Zinc coating for steel parts	gm/m^2	600
b)	Purity of Zinc used for galvanising	%	99.95 (IS 209) or 98.5 (IS 13229)
c)	Min. No. of dips in standard preece test the ferrous parts can withstand (wherever applicable)	No.	a) Fasteners: 4 dips of 1 minute b) Spring washers: 3 dips of 1 minute & c) all others: 6 dips of 1 minute

CHAPTER 44: TECHNICAL SPECIFICATION OF DISC INSULATORS FOR SUBSTATION AND TRANSMISSION LINE WORKS

44.1.0 SCOPE.

44.1.1 This specification provides for design, manufacture, engineering, inspection and testing before dispatch, packing and delivery at site, testing and commissioning for manufacturers of disc Insulators as per technical requirements furnished in this specification.

These insulators are to be used in suspension and tension insulator strings for the suspension and anchoring of the conductors on EHV transmission line towers.

44.1.2 Following are the list of documents constituting this package.

(i) Technical specification.

(ii) Technical data sheet.

(iii) Drawings of insulators

44.1.3 All the above volumes along with amendments there of shall be read and interpreted together. However, in case of a contradiction between the “Technical Specification” and any other volume, the provisions of this volume will prevail.

44.1.4 The insulators shall conform in all respects to high standards of engineering, design, workmanship and latest revisions of relevant standards at the time of offer and purchaser shall have the power to reject any work or material which in his judgment, is not in full accordance therewith.

44.2.0 STANDARDS:

44.2.1 Except as modified in this specification, the disc/porcelain long rod insulators shall conform to the following Indian Standards, which also includes latest revisions and amendments if any. Equivalent International and Internally recognized standards to which some of these standards generally correspond are also listed below.

Sl. No.	Indian Standard	Title.	International Standard.
1.	IS: 206	Method for Chemical Analysis of Slab Zinc.	
2.	IS: 209	Specification for Zinc.	BS: 3436
3.	IS: 731	Porcelain insulators for overhead power lines with a normal voltage greater than 1000V	BS: 137(I&II); IEC 60274 IEC 60383
4.	IS: 2071 Part-(I)	Method of High Voltage Testing.	
	Part-(II) Part-(III)		
5.	IS: 2121 (Part-I)	Specification of Conductors and Earth wire Accessories for Overhead Power lines. Armour Rods, Binding wires and tapes for conductor.	

6.	IS: 2486	Specification for Insulator fittings for overhead power lines with a nominal voltage greater than 1000V.	
	Part – I	General Requirement and Tests.	BS: 3288
	Part – II	Dimensional Requirements.	IEC: 60120
	Part – III	Locking devices.	IEC: 60372
7.	IS: 2629	Recommended practice for Hot Dip Galvanisation for iron and steel.	
8.	IS: 2633	Testing for Uniformity of Coating of Zinc coated articles.	
9.	IS: 3138	Hexagonal Bolts & Nuts.	ISO/R 947 & ISO/R 272
10.	IS: 3188	Dimensions for Disc Insulators.	IEC: 60305
11.	IS: 4218	Metric Screw Threads	ISO/R 68-1969 R 26-1963, R 262-1969 & R965-1969
12.	IS: 6745	Determination of weight of zinc coating on zinc coated iron and steel articles.	
13.	IS: 8263	Methods of RIV Test of HV insulators.	IEC 60437 NEMA Publication No.107/1964 CISPR
14.	IS: 8269	Methods for switching impulse Test on HV insulators.	IEC: 60506
15.		Thermal mechanical performance test and mechanical performance test on string insulator units.	IEC: 60575
16	IEC	Ceramic Long Rod Insulators	IEC: 60433

44.2.2 The standards mentioned above are available from

Reference.	Name & Address:
BS	British Standards, British Standards Institution, 101, Pentonvile Road, N- 19 ND,U.K
IEC / CISPR	International Electro technical commission Electro Technique International. 1, Rue de verembe Geneva SWITZERLAND.

IS	Bureau of Indian Standards, Manak Bhavan, 9 Bahadurshah Zafar Marg, New Delhi-110001,
ISO	International Organisation for Standardization. Danish Board of Standardization Dansk Standardizing Sraat Aurehoegvej-12 DK-2900 Helleprup DENMARK.

44.3.0 PRINCIPAL PARAMETERS.

44.3.1 DETAILS OF DISC INSULATORS:

44.3.1.1 The Insulator strings shall consist of standard discs for use in three phases. 50 Hz effectively earthed 33/132/220 KV transmission system of AEGCL in a moderately polluted atmosphere. The discs shall be cap and pin, ball and socket type. Radio interference data and have characteristics as shown in Table-I and all ferrous parts shall be hot dip galvanized as per the latest edition of IS 2629. The zinc to be used for making sleeves shall be 99.95 % pure.

44.3.1.2 The size of disc insulator, minimum creepage distance the number to be used in different type of strings, their electromechanical strength and mechanical strength of insulator string along with hardware shall be as follows:

PRINCIPAL PARAMETERS OF THE DISC INSULATORS:-

Sl. No.	Type of String.	Size of disc. Insulator (mm)	Minimum creepage distance of each disc (mm),	No. of standard discs 132 KV /220 KV/400kV	Electro-mechanical strength of insulator string fittings (KN)
1.	Single suspension	255 x 145	320	1x9/1x14 /-	70 KN/90 KN Normal Disc Insulator
2.	Double suspension.	-do-	-do-	2x9/2x14 /-	70 KN/90 KN Normal Disc Insulator
3	Single suspension	255 x 145	430	1x9/1x14 /-	70 KN/90 KN Antifog Insulator
4	Double suspension.	-do-	-do-	2x9/2x14 /-	70 KN/90 KN Antifog Disc Insulator
5.	Single Suspension	280 x 145	430	1x10/1x15 /-	120 KN Anti fog Disc insulator

6.	Double suspension	280 x 145	430	2x10/2x15 /-	120 KN Anti fog Disc insulator
7.	Single Tension	305 X 170	475	1x10/1x15/1x25	160 KN Anti fog Disc insulator
8.	Double Tension	305 X 170	475	2x10/2x15/2x25	160 KN Anti fog Disc insulator
9.	Single Suspension	280 x 145	430	1x10/1x15/1x25	120 KN Anti fog Disc insulator
10.	Double suspension	280 x 145	430	2x10/2x15/2x25	120 KN Anti fog Disc insulator

44.3.2 SPECIFICATION DRAWINGS:

44.3.2.1: The Specification in respect of the disc insulators are described, the specification is for information and guidance of the bidder only. The drawings to be furnished by the supplier shall be as per his own design and manufacture and in line with the specification.

44.4.1 Porcelain glaze:

The finished porcelain shall be glazed in brown colour. The glaze shall cover all exposed parts of the insulator and shall have a good lusture, smooth surface and good performance under the extreme weather conditions of a tropical climate. It shall not crack or chip by ageing under the normal service conditions. The glaze shall have the same coefficient of expansion as of the porcelain body throughout the working temperature range.

44.4.2 METAL PARTS:

44.4.2.1 Cap and Ball Pins:

Ball pins shall be made with drop forged steel caps with malleable cast iron. They shall be in one single piece and duly hot dip galvanized. They shall not contain parts or pieces joined together welded, shrink fitted or by any other process from more than one piece of materials. The pins shall be of high tensile steel, drop forged and heat-treated. The caps shall be cast with good quality black heart malleable cast iron and annealed. Galvanizing shall be by the hot dip process with a heavy coating of zinc of very high purity. The bidder shall specify the grade composition and mechanical properties of steel used for caps and pins. The cap and pin shall be of such design that it will not yield or distort under the specified mechanical load in such a manner as to change the relative spacing of the insulators or add other stresses to the shells. The insulator caps shall be of the socket type provided with nonferrous metal or stainless-steel cotter pins and shall provide positive locking of the coupling.

44.4.2.2 Security Clips:

The security clips shall be made of phosphor bronze or of stainless steel.

44.4.3 FILLER MATERIAL:

Cement to be used, as a filler material be quick setting, fast curing Portland cement. It shall not cause fracture by expansion or loosening by contraction. Cement shall not react chemically with metal parts in contact with it and its thickness shall be as small and as uniform as possible.

44.4.4 MATERIALS DESIGN AND WORKMANSHIP:

44.4.4.1 GENERAL:

(I) All raw materials to be used in the manufacture of these insulators shall be subject to strict raw material quality control and to stage testing/ quality control during manufacturing stage to ensure the quality of the final end product. Manufacturing shall conform to the best engineering practices adopted in the field of extra high voltage transmission. Bidders shall therefore offer insulators as are guaranteed by them for satisfactory performance on Transmission lines.

(II) The design, manufacturing process and material control at various stages be such as to give maximum working load, highest mobility, best resistance to corrosion, good finish elimination of sharp edges and corners to limit corona and radio interference voltages.

44.4.4.2 INSULATOR SHELL:

The design of the insulator shells shall be such that stresses due to expansion and contraction in any part of the insulator shall not lead to deterioration. Shells with cracks shall be eliminated by temperature cycle test followed by mallet test. Shells shall be dried under controlled conditions of humidity and temperature.

44.4.4.3 METAL PARTS:

i) The pin and cap shall be designed to transmit the mechanical stress to the shell by compression and develop uniform mechanical strength in the insulator. The cap shall be circular with the inner and outer surfaces concentric and of such design that it will not yield or distort under loaded conditions. The head portion of the pinball shall be suitably designed so that when the insulator is under tension the stresses are uniformly distributed over the pinhole portion of the shell. The pinball shall move freely in the cap socket either during assembly of a string or during erection of a string or when a string is placed in position.

ii) Metal caps shall be free from cracks, seams, shrinks, air holes, blowholes and rough edges. All metal surfaces shall be perfectly smooth with no projecting part or irregularities, which may cause corona. All load bearing surfaces shall be smooth and uniform so as to distribute the loading stress uniformly. Pins shall not show any microscopically visible cracks, inclusions and voids.

44.4.4.4 GALVANIZING:

All ferrous parts, shall be hot dip galvanized in accordance with IS: 2629. The zinc to be used for galvanizing shall conform to grade Zn 99.95 as per IS: 209. The zinc coating shall be uniform, smoothly adherent, reasonably light, continuous and free from impurities such as flux, ash, rust stains, bulky white deposits and blisters. Before ball fittings are galvanized, all die flashing on the shank and on the bearing surface of the ball shall be carefully removed without reducing the designed dimensional requirements.

44.4.4.5 CEMENTING:

The insulator design shall. Be such that the insulating medium shall not directly engaged with hard metal. The surface of porcelain and coated with resilient paint to offset the effect of difference in thermal expansions of these materials. High quality Portland cement shall be used for cementing the porcelain to the cap & pin.

44.4.4.6 SECURITY CLIPS (LOCKING DEVICES)

The security clips to be used as locking device for ball and socket coupling shall be „R" shaped hump type to provide for positive locking of the coupling as per IS: 2486 (Part-IV). The legs of the security clips shall allow for spreading after installation to prevent complete withdrawal from the socket. The locking device shall resilient corrosion resistant and of sufficient mechanical strength. There shall be no possibility of the locking device to be displaced or be capable of rotation, which placed in position, and under no circumstances shall it allow separation of insulator units and fittings. „W" type security clips are also acceptable. The hole for the security clip shall be counter sunk and the clip shall be of such design that the eye of the clip may be engaged by a hot line clip puller to provide for disengagement under energized conditions. The force required for pulling the clip into its unlocked positions shall not be less than 50 N (5 kg.) or more than 500 N (50 kgs.).

44.4.4.7 MARKING:

Each insulator shall have the rated combined mechanical and electrical strength marked clearly on the porcelain surface. Each insulator shall also bear symbols identifying the manufacturer, month, and year of manufacture. Marking on porcelain shall be printed, not impressed, and shall be applied before firing

44.4.5 BALL AND SOCKET DESIGNATION:

The dimensions of the ball and sockets for 70 and 90 KN insulator strings shall be of 16 mm and for 120 KN and 160 KN insulator strings shall be of 20 mm designation in accordance with the standard dimensions stated in IS: 2486 (Part-II).

44.4.6-DIMENSIONAL TOLERANCE OF INSULATOR DISCS:

It shall be ensured that the dimensions of the disc insulators are within the limits specified below:

Sl. No.	Diameter of Disc (mm)	Standard in Mm	Maximum	Minimum
1.	70 KN/90 KN & 120 KN	**255/255 & 280**	As per IS	As per IS
2.	160 KN	305	As per IS	As per IS
(b)				
Sl. No.	Ball to Ball spacing Between Discs (mm)	Standard in Mm	Maximum	Minimum
1.	70 KN/90 KN/120 KN	**145**	As per IS	As per IS
2.	160 KN	170	As per IS	As per IS

NOTE: Tolerance as per relevant IS (Latest edition).

(44.4.7) GUARANTEED TECHNICAL PARTICULARS FOR ANTIFOG DISC INSULATORS

Sl. No.	DESCRIPTION	70 KN	90 KN	120KN	160 KN
1.	Manufacture‟s name &address				
2	Type of Insulator	Ball & Socket	Ball & socket	Ball & socket	Ball & socket
3	Size of ball & socket	16B	16B	20	20
4	Dimensions				
(a)	Disc diameter	255	255	280	305
(b)	Unit spacing	145	145	145	170
(c)	Creepage distance of the single insulator-mm	430	430	430	475
5	Electro-mechanical strength of single insulator-kN	70	90	120	160
6	Materials of shell	Porcelain	Porcelain	Porcelain	Porcelain
7	**Electrical value**				
7.1	Power frequency Withstand Voltage Disc				
	(a) Dry-kV (rms)	80	80	85	90
	(b) Wet-kV (rms)	45	45	50	50
7.2	Power frequency Flashover Voltage Disc				
	(a) Dry-kV (rms)	85	85	90	95
	(b) Wet-kV (rms)	50	50	55	55
7.3	Impulse Withstand Voltage Disc				
	1.2/50 micro second				
	(a) Positive – kV(Peak)	125	125	130	135
	(b) Negative – kV(Peak)	125	125	130	135
7.4	Impulse Flashover Voltage Disc				
	1.2/50 micro second				
	(a) Positive – kV(Peak)	135	135	140	145
	(b) Negative – kV(Peak)	130	130	135	140

44.4.8 INTERCHANGEABILITY:

The insulators inclusive of the ball and socket fittings shall be of standard design suitable for use with hardware fittings of any make conforming to relevant Indian Standards.

44.4.9 CORONA AND RIV PERFORMANCE:

All surfaces shall be even, smooth, without cuts, abrasions or projections. No part shall be subject to excessive localized pressure. The metal parts and porcelain shall not produce any noise-generating corona under all operating conditions

44.5.0 SUITABILITY FOR LIVE LINE MAINTENANCE:

The insulator shall be compatible for use with hot line or live line maintenance techniques so that usual hot line operation can be carried out with easy speed and safety.

44.5.1 FREEDOM FROM DEFECTS:

Insulators shall have none of the following defects:

1) Ball pin shake.
2) Cementing defects near the pin like small blow holes, small hair cracks lumps etc.
3) Sand fall defects on the surface of the insulator.

44.5.2 INSULATOR STRINGS:

44.5.2.1 TYPE AND RATING:

The insulator strings shall be formed with standard discs described in this specification for use on 3 phases 132/220 KV 50 Hz effectively earthed systems in an atmosphere with pollution level as indicated in project synopsis. Suspension insulator strings for use with suspension/tangent towers are to be fitted with discs 70/90 KN EMS rating while tension insulator strings for use with Anchor/ Tension towers are to be fitted with discs of 120 KN / 160 KN EMS level rating.

44.5.2.2 STRING SIZE:

The sizes of the disc insulator, the number to be used in different types of strings, their electro-mechanical strength and minimum nominal creep age distance shall be as given in clause 44.3.1.2.

44.5.3 STRING CHARACTERISTICS

44.5.3.1 The characteristics of the complete string shall be as follows:

Sl. No.	**Description.**	**Suspension.**		**Tension.**	
		132KV	**220kV**	**132KV**	**220KV**
I	Switching surge withstand voltage (dry& wet) KV Peak	-	-	-	-
II	Lighting impulse withstand voltage (dry) KV Peak.	650	1050	650	1050
III	Power frequency without voltage (wet) KV r.m.s.	275	460	275	460
IV.	Corona extinction voltage level KV rms	-	176	-	176

V	Max. RIV for comp. Etc. strong including corona rings at 156 KV (rms). … hours clamps etc. at 1.1. times maximum knee to ground voltage (micro volts).	-	500	-	500
VI.	Mechanical failing load for each string (kgf)	6500	11500	11500	15500
VII.	No deformation load for each string (kgf)	-	7705	-	10385
VIII	Max. voltage across any disc.	13%	13%	13%	13%

44.5.3.2 Insulator units after assembly shall be concentric and coaxial within limits as permitted by Indian Standards.

44.5.3.3 The strings design shall be such that when units are coupled together there shall be contact between the shell of one unit and metal of the adjacent unit.

CHAPTER 45: TECHNICAL SPECIFICATION OF PORCELAIN LONG ROD INSULATORS

45.1.1 Details of Long Rod Insulators

45.1.2 The insulator string shall consist of standard porcelain long rod insulators with normal sheds for a three phase, 50 Hz, effectively earthed 132/220/400 kV transmission system. Insulators shall be long rod type with Ball and socket connections.

45.1.3 Insulators shell has normal sheds/alternate sheds with good self-cleaning properties. Insulator shed profile, spacing projection etc. shall be strictly in accordance with the recommendation of IEC-60815.

45.1.4 The size of long rod insulator, minimum creepage distance, the number to be used in different type of strings, their electromechanical strength and mechanical strength of insulator string along with hardware fittings shall be as follows:

45.1.5 Description of long rod insulator string (equivalent to disc insulator string)

Sl. No.	System Voltage (kV)	Type of String.	Length of Porcelain long rod Insulator (mm)	Minimum creepage distance of Porcelain long rod Insulator(mm),	No. of Porcelain long rod Insulator units per string	Electro-mechanical strength of Porcelain long rod Insulator string fittings (KN)
1.	132	Single Suspension	1305	2628	1 X 1	1 X 70kN
2.	132	Double Suspension	1305	2628	2 X 1	2 X 70kN
3.	132	Single Tension	1450	2920	1 X 1	1 X 120kN
4.	132	Double Tension	1450	2920	2 X 1	2 X 120kN
5.	132	Single Suspension	1305	3625	1 X 1	1 X 70kN
6.	132	Double Suspension	1305	3625	2 X 1	2 X 70kN
7.	132	Single Tension	1450	3625	1 X 1	1 X 120kN
8.	132	Double Tension	1450	3625	2 X 1	2 X 120kN
9.	132	Single Tension	1700	3625	1 X 1	1 X 160kN
10.	132	Double Tension	1700	3625	2 X 1	2 X 160kN
11.	220	Single Suspension	2030	4088	1 X 2	1 X 90kN
12.	220	Double Suspension	2030	4088	2 X 2	2 X 90kN
13.	220	Single Tension	2175	4380	1 X 2	1 X 120kN
14.	220	Double Tension	2175	4380	2 X 2	2 X 120kN
15.	220	Single	2030	5180	1 X 2	1 X 90kN

		Suspension				
16.	220	Double suspension	2030	5180	2 X 2	1 X 90kN
17.	220	Single Tension	2175	5550	1 X 2	1 X 120kN
18.	220	Double Tension	2175	5550	2 X 2	2 X 120kN
19.	220	Single Tension	2550	5550	1 X 2	1 X 160kN
20.	220	Double Tension	2550	5550	2 X 2	2 X 160kN
21.	400	Single Suspension	3335	9200	1 X 3	1 X 120kN
22.	400	Double suspension	3335	9200	2 X 3	2 X 120kN
23.	400	Single Tension	3910	9200	1 X 3	1 X 160kN
24.	400	Double Tension	3910	9200	2 X 3	2 X 160kN

(i) Bidders may quote for the relevant strings.

(ii) Length of long rod insulator strings shall be matching with the corresponding disc insulator strings.

45.2.1 STANDARD TECHNICAL PARTICULAR FOR 132 KV LONG ROD INSULATORS

Sl.	**Description**	**Unit**	**Standard Technical Particular value**		
			70 KN/ 90KN Insulator	**120 KN Insulator**	**160 KN Insulator**
1.0	**General**				
a)	Size and Designation of ball & Socket assembly	mm	16 mm Alt-B as per IS 2486 / IEC: 60120	20 as per IS 2486/ IEC: 60120	20 as per IS 2486/ IEC: 60120
2.0	**Dimensions**				
a)	Core diameter	mm	55 to 75	60 to 75	75 to 85
b)	Tolerance on core diameter	± mm	(0.04d+1.5)	(0.04d+1.5)	(0.04d+1.5)
c)	Minimum nominal creepage distance 1. Normal	mm	2628	2920	-----
	2. Anti Fog		3625	3625	3625
3.0	Colour of glaze of finished porcelain insulator		Brown	Brown	Brown
4.0	Mechanical Strength of Long Rod	kN	70	120	160
5.0	**Minimum electrical values**				
a)	Power frequency **Withstand** voltage	kV rms	310/275	310/275	310/275

b)	Power frequency **Flashover** voltage (DRY/WET)	kV rms	325/295	325/295	325/295
c)	Impulse **Withstand** test voltage 1.2 x 50 μs (Dry) POSITIVE / NEGATIVE	kV(peak)	650/650	650/650	650/650
d)	Impulse **Flashover** test voltage 1.2 x 50 μs (Dry) POSITIVE / NEGATIVE	kV(peak)	670/670	670/670	670/670
6.0	Eccentricity of Long Rod				
a)	Max. axial/radial run out		1.2 % of insulator length	1.2 % of insulator length	1.2 % of insulator length
b)	Max. angular displacement	deg	15	15	15
7.0	Galvanizing				
a)	Minimum mass of zinc coating	Gm/ sq.m.	600	600	600
b)	Minimum no. of one-minute dips in the standard preece test	Nos.	6 dips	6 dips	6 dips
c)	Minimum purity of zinc used for galvanizing	%	99.95	99.95	99.95

45.2.2 STANDARD TECHNICAL PARTICULAR FOR 220 KV LONG ROD INSULATORS

Sl.	Description	Unit	Standard Technical Particular value			
			70 KN Insulator	**90 KN Insulator**	**120 KN Insulator**	**160 KN Insulator**
1.0	**General**					
a)	Size and Designation of ball & Socket assembly	mm	-----	16 mm Alt- B as per IS 2486/ IEC: 60120	20 as per IS 2486/ IEC: 60120	20 as per IS 2486/ IEC: 60120
2.0	**Dimensions**		-----			
a)	Core diameter	mm	-----	55 to 75	60 to 75	75 to 85
b)	Tolerance on core diameter	± mm	-----	(0.04d+1.5)	(0.04d+1.5)	(0.04d+1.5)
c)	Minimum nominal creepage distance 1. Normal	mm	-----	4088	4380	-----
	2. Anti Fog		-----	5180	5550	5550
3.0	Colour of glaze of finished porcelain insulator		-----	Brown	Brown	Brown

4.0	Mechanical Strength of Long Rod	kN	-----	90	120	160
5.0	**Minimum electrical values**		-----			
a)	Power frequency **Withstand**	kV	-----	500/460	500/460	500/460
b)	Power frequency **Flashover**	kV	-----	520/480	520/480	520/480
c)	Impulse **Withstand** test voltage 1.2 x 50 µs (Dry) POSITIVE / NEGATIVE	kV(peak)	-----	1050/1050	1050/1050	1050/1050
d)	Impulse **Flashover** test voltage 1.2 x 50 µs (Dry) POSITIVE / NEGATIVE	kV(peak)	-----	1100/1100	1100/1100	1100/1100
e)	Corona extinction voltage level	kV	-----	156	156	156
f)	Max. RIV for string including corona rings at 156kV rms	micro volts	-----	500	500	500
6.0	**Eccentricity of Long Rod**					
a)	Max. axial/radial run out			1.2 % of insulator length	1.2 % of insulator length	1.2 % of insulator length
b)	Max. angular displacement	deg	-----	15	15	15
7.0	Galvanizing					
a)	Minimum mass of zinc coating	Gm/ sq.m.	-----	600	600	600
b)	Minimum no. of one minute dips in the standard preece test	Nos.	-----	6 dips	6 dips	6 dips
c)	Minimum purity of zinc used for galvanizing	%	-----	99.95	99.95	99.95

45.2.3 STANDARD TECHNICAL PARTICULAR FOR 400 KV LONG ROD INSULATOR STRING

Sl.	**Description**	**Unit**	**Standard Technical Particular value**			
			70 KN Insulator	**90 KN Insulator**	**120 KN Insulator**	**160 KN Insulator**
1.0	**General**					

a)	Size and Designation of ball & Socket assembly	mm	-----	-----	20 as per IS 2486/ IEC: 60120	20 as per IS 2486/ IEC: 60120
2.0	**Dimensions**		-----	-----		
a)	Core diameter	mm	-----	-----	60 to 75	75 to 85
b)	Tolerance on core diameter	± mm	-----	-----	(0.04d+1.5)	(0.04d+1.5)
c)	Minimum nominal creepage distance 1. Normal	mm	-----	-----	-----	-----
	2. Anti Fog		-----	-----	9200	9200
3.0	Colour of glaze of finished porcelain insulator		-----	-----	Brown	Brown
4.0	Mechanical Strength of Long Rod	kN	-----	-----	120	160
5.0	**Minimum electrical values**		-----	-----		
a)	Power frequency **Withstand** voltage	kV rms	-----	-----	720/680	720/680
b)	Power frequency **Flashover** voltage	kV rms	-----	-----	740/700	740/700
c)	Impulse **Withstand** test voltage 1.2 x 50 µs (Dry) POSITIVE / NEGATIVE	kV(peak)	-----	-----	1550/1550	1550/1550
d)	Impulse **Flashover** test voltage 1.2 x 50 µs (Dry) POSITIVE / NEGATIVE	kV(peak)	-----	-----	1600/1600	1600/1600
e)	Wet Switching impulse withstand voltage (POSITIVE / NEGATIVE)	kV(peak)	-----	-----	1050/1050	1050/1050
f)	Corona extinction voltage level	kV rms	-----	-----	320	320
g)	Max. RIV for string including corona rings at 320kV rms	micro volts	-----	-----	1000	1000
6.0	**Eccentricity of Long Rod**					

a)	Max. axial/radial run out		-----	-----	1.2 % of insulator length	1.2 % of insulator length
b)	Max. angular displacement	deg	-----	-----	15	15
7.0	**Galvanizing**					
a)	Minimum mass of zinc coating	Gm/	-----	-----	600	600
b)	Minimum no. of one minute dips in	Nos.	-----	-----	6 dips	6 dips
c)	Minimum purity of zinc used for	%	-----	-----	99.95	99.95

45.2.0 SPECIFICATION DRAWINGS:

This specification is for information and guidance of the bidder only. The drawings to be furnished by the supplier shall be as per his own design and manufacture and shall be in line with the specification.

45.3.0 GENERAL TECHNICAL REQUIREMENTS:

45.3.1 PORCELAIN:

The porcelain used in the manufacture of the shell shall be nonporous of high dielectric, mechanical and thermal strength free from internal stress blisters and thermal strength from internal stresses blisters, laminations, voids, foreign matter. Imperfections or other defects, which might render it in any way unsuitable for insulator shells. Porcelain shall remain unaffected by climatic conditions, ozone, acid alkalis, and zinc of dust. The manufacturing shall be by the wet process and impervious character obtained by through vitrification.

45.3.2 PORCELAIN GLAZE:

Surfaces to come in contact with cement shall be made rough by stand glazing. All other exposed surfaces shall be glazed with ceramic materials having the same temperature coefficient of expansion as that of the insulator shell. The thickness of the glaze shall be uniform throughout and the colour of the glaze shall be brown. The glaze shall have a visible lustre and smooth on surface and be capable of satisfactory performance under extreme tropical climatic weather conditions and prevent ageing of the porcelain. The glaze shall remain under compression on the porcelain body throughout the working temperature range.

45.3.3 METAL PARTS:

45.3.3.1 Cap and Ball pins:

Twin Ball pins shall be made with drop forged steel and caps with malleable cast iron. They shall be in one single piece and duly hot dip g galvanized. They shall not contain parts or pieces joined together, welded, shrink fitted or by any other process from more than one piece of material. The pins shall be of high tensile steel, drop forged and heat malleable cast iron and annealed. Galvanizing shall be by the hot dip process with a heavy coating of zinc of very high purity with minimum of 6 dips. The bidder shall specify the grade, composition and mechanical properties of steel used for caps and pins.

45.3.3.2 SECURITY CLIPS:

The security clips shall be made of phosphor bronze or of stainless steel.

45.3.4 FILLER MATERIAL:

Cement to be used as a filler material shall be quick setting, for curing Portland cement. It shall not cause fracture by expansion or loosening by contraction. Cement shall not react chemically with metal parts in contract with it and its thickness shall be as small and as uniform as possible.

45.4.0 MATERIAL DESIGN AND WORKMANSHIP:

45.4.1 GENERAL:

i) All raw materials to be used in the manufacture of these insulators shall be subject to strict raw materials quality control and to stage testing quality control during manufacturing stage to ensure the quality of the final end product. Manufacturing shall conform to the best engineering practices adopted in the field of extra high voltage transmission. Bidders shall therefore offer insulators as are guaranteed by them for satisfactory performance on Transmission lines.

ii) The design, manufacturing process and material control at various stages be such as to give maximum working load, highest mobility, best resistance to corrosion good finish, elimination of sharp edges and corners to limit corona and radio interference voltage.

45.4.2 INSULATOR SHELL:

The design of the insulator shell shall be such that stresses due to expansion and contraction in any part of the insulator shall not lead to deterioration. Shells with cracks shall be eliminated by temperature cycle test followed by temperature cycle test followed by mallet test. Shells shall be dried under controlled conditions of humidity.

45.4.3 METAL PARTS:

i) The twin ball pin and cap shall be designed to transmit the mechanical stresses to the shell by compression and develop uniform mechanical strength in the insulator. The cap shall be circular with the inner and outer surfaces concentric and of such design that it will not yield or distort under loaded conditions. The head portion of the insulator or is under tension the stresses are uniformly distributed over the pinhole portion of the shell. The pinball shall move freely in the cap socket either during assembly of a string or during erection of a string or when a string is placed in position.

ii) Metal caps shall be free from cracks, seams, shrinks, air holes, blowholes and rough edges. All metal surfaces shall be perfectly smooth with no projecting parts or irregularities which may cause corona. All load bearing surfaces shall be smooth and uniform so as to distribute the loading stresses uniformly. Pins shall not show any macroscopically visible cracks, insulations and voids.

45.4.4 GALVANIZING:

All ferrous parts shall be hot dip galvanized six times in accordance with IS: 2629. The zinc to be used for galvanizing shall conform to grade Zn 99.5 as per IS: 209. The zinc coating shall be uniform, smoothly adherent, reasonably light, continuous and free from impurities such as flux ash, rust stains, bulky white deposits and blisters. Before ball fittings are galvanized, all die flashing on the shank and on the bearing surface of the ball shall be carefully removed without reducing the designed dimensional requirements.

45.4.4.1 CEMENTING:

The insulator design shall be such that the insulating medium shall not directly engage with hard metal. The surfaces of porcelain and coated with resilient paint to offset the effect of difference in thermal expansions of these materials.

45.4.5 SECURITY CLIPS (LOCKING DEVICES)

The security clips to be used as locking device for ball and socket coupling shall be „R‟ shaped hump type to provide for positive locking of the coupling as per IS: 2486 (Part-IV). The legs of the security clips shall allow for sore adding after installation to prevent complete withdrawal from the socket. The locking device shall be resilient corrosion resistant and of sufficient mechanical strength. There shall be no possibility of the locking device to be displaced or be capable of rotation when placed in position and under no circumstances shall it allow separation of insulator units and fitting „W‟ type security clips are also acceptable. The hole for the security clip shall be countersunk and the clip shall be of such design that the eye of the clip may be engaged by a hot line clip puller to provide for disengagement under energized conditions. The force required for pulling the clip into its unlocked position shall not be less than 50 N (5 Kgs.) or more than 500N (50 Kgs.)

45.4.6 BALL AND SOCKET DESIGNATION:

The dimensions of the balls and sockets for 80 KN long rod insulators shall be of 16mm and for 120 KN shall be of 20mm designation in accordance with the standard dimensions stated in IS: 2486 (Part-III).

45.4.7-DIMENSIONAL TOLERANCE OF PORCELAIN LONG ROD INSULATORS

It shall be ensured that the dimensions of the long rod insulators are within the limits as per relevant IEC/ ISS.

45.5.0 TESTS (FOR DISC/ LONG ROD PORCELAIN INSULATORS):

45.5.1 The following tests shall be carried out on the insulator string and disc insulators.

45.5.2 TYPE TEST:

This shall mean those tests, which are to be carried out to prove the design, process of manufacture and general conformity of the material and product with the intents of this specification. These tests shall be conducted on a representative number of samples prior to commencement of commercial production. The Bidder shall indicate his schedule for carrying out these tests.

45.5.3 ACCEPTANCE:

This shall mean these tests, which are to be carried out on samples taken from each lot offered for pre-despatch inspection for the purpose of acceptance of the lot.

45.5.4 ROUTINE TESTS:

This shall mean those tests, which are to be carried out on each insulator to check the requirements, which are likely to vary during production.

45.5.5 TESTS DURING MANUFACTURE:

Stage tests during manufacture shall mean those tests, which are to be carried out during the process of manufacture to ensure quality control such that the end product is of the designed quality conforming to the intent of this specification.

45.5.6 TEST VALUE:

For all type and acceptance tests the acceptance values shall be the value guaranteed by the bidder in the guaranteed technical particulars of the acceptance value specified in this specification of the relevant standard whichever is more stringent for that particular test.

45.5.7 TEST PROCEDURE AND SAMPLING NORMS:

The norms and procedure of sampling for the above tests shall be as per the relevant Indian Standard or the internationally accepted standards. This will be discussed and mutually agreed to between the supplier and purchaser before placement of order. The standards and normal according to which these tests are to be carried out are listed against each test.

45.5.8 TYPE TESTS:

The following type test shall be conducted on a suitable number of individual unit components, materials or complete strings.

45.5.8.1 On the complete insulator string with hardware fittings.

a)	Power frequency voltage withstand test with corona control rings and under wet condition.	: IEC: 60383
b)	Switching surge voltage withstand test under wet condition (For 400kV and above only)	: IEC: 60383
c)	Impulse voltage withstand test under dry condition.	: IEC: 60383
d)	Impulse voltage flashover test under dry condition.	: IEC: 60383
e)	Voltage distribution test.	: Applicable only for Disc insulators only
f)	Corona & RIV test under dry condition.	: As per this specification
g)	Mechanical strength test.	: As per this specification
h)	Vibration.	: As per this specification

45.5.8.2 On Insulators:

a)	Verification of dimensions.	: IS: 731/ IEC: 60383
b)	Thermal mechanical performance test:	: IEC:60575
c)	Power frequency voltage withstand and flashover (I) dry (ii) wet.	: IEC: 60383
d)	Impulse voltage withstand flashover test (dry)	: IEC: 60383

e) Visible discharge test (dry) : IS:731
f) RIV test (dry) : IS:8263/ IEC: 60437

45.5.9 ACCEPTANCE TESTS:

45.5.9.1 For insulator:

a) Visual examination : IS:731/IEC:60383

b) Verification of dimensions. : IS:731/IEC:60383

c) Temperature cycle test. : IS:731/IEC:60383

d) Galvanizing test. : IS:731/IEC:60383

e) Mechanical performance test. : IEC:60575

f) Test on locking device for ball and socket coupling. : IEC:60372

g) Eccentricity test. : IEC: 60383

h) Electro-mechanical/Mechanical strength test. : IEC: 60383 (Disc/Long Rod)

i) Puncture test. : IS:731 (Applicable only for Discs)

j) Porosity test. : IS:731/IEC:60383

45.5.10 ROUTINE TESTS:

45.5.10.1

For insulators :

a) Visual inspection. : IS:731/IEC:60383

b) Mechanical routine test. : IS:731/IEC:60383

c) Electrical routine test. : IEC:60383 (Applicable only for Discs)

45.5.11 TEST DURING MANUFACTURE: On all components as applicable.

a) Chemical analysis of zinc used for galvanizing. : As per the Specification

b) Chemical analysis, mechanical and metallographic test & magnetic particle inspection for malleable casting : As per the Specification

c) Chemical analysis , hardness test & magnetic particle inspection of forging. : As per specifications

d) Hydraulic Internal Pressure tests on shell : As per specifications

e) Crack detection test for metal parts. : As per specifications

45.5.12 ADDITIONAL TEST:

The purchaser reserves the right for carrying out any other tests of a reasonable nature at the works of the supplier/ laboratory or at any other recognized laboratory/ research institute in addition to the above mentioned type, acceptance and routine tests at the cost of the purchaser to satisfy that the material complies with the intent of this specification.

45.5.13 CO-ORDINATION FOR TESTING:

For insulator strings, the supplier shall arrange to conduct testing of their Porcelain disc / long rod insulators with the hardware fittings to be supplied to the purchaser by other suppliers. The supplier is also required to guarantee overall satisfactory performance of the disc/ long rod insulator with the hardware fittings.

NOTE:

In respect of electrical tests on a complete string consisting of insulators and hardware guarantee of values of responsibility of testing shall be with hardware manufacturer of RIV, corona and voltage distribution test (Applicable for Disc insulator strings only) and with insulator manufacturer for all other tests.

45.5.14 TEST CHARGES AND TEST SCHEDULE:

45.5.14.1 TYPE TEST:

The insulator offered shall be fully type tested as per this specification. In case the equipment of the type and design offered, has already been type tested in an independent test laboratory. The bidder shall furnish four sets of type test reports alongwith the offer. These tests must not have been conducted earlier than five years. The purchaser reserves the right to demand repetition of some or all type tests in the presence of purchasers‟ carrying representative. For this purpose the bidder may quote unit rates for carrying out each type test. These prices shall be taken into consideration for bid evaluation. For any change in the design/type already type tested and the design/type offered against this specification, purchaser reserves the right to demand repetition of tests without any extra cost.

45.5.14.2 ACCEPTANCE AND ROUTINE TEST:

All acceptance and routine tests as stipulated herein shall be carried out by the supplier in the presence of purchaser’s representative.

45.5.14.3 Immediately after finalisation of the programme of type/ acceptance/ routine testing, the supplier shall give sufficient advance intimation to the purchaser to enable him to depute his representative for witnessing the tests.

For type tests involving tests on a complete insulator string with hardware fittings, the purchaser will advice the supplier of the hardware fittings to provide the necessary fittings to the place of the test.

45.5.14.4 In case of failure of the complete string in any type tests, the supplier whose product has failed in the tests, shall get the tests repeated at his cost. In case of any dispute, assessment of the purchaser as to the items that has caused the failure in any of the type tests shall be final and binding.

45.6.1 INSPECTION:

i. Purchaser and its representative shall at all times be entitled to have access to the works and to all places of manufacturer where insulators are manufactured and the supplier shall afford all facilities to them for unrestricted inspection of the works, inspection of materials, inspection of manufacturing process of insulators and for conducting necessary tests as specified herein.

ii. The supplier shall keep the purchaser informed in advance of the time of starting and of progress of manufacture of insulators in its various stages so that arrangements could be made for inspection.

iii. No material shall be dispatched from its point of manufacture unless the materials has been satisfactorily inspected and tested.

iv. The acceptance of any quantity of insulators shall in no way relieve the supplier of his responsibility for meeting all the requirement of this specification and shall not prevent subsequent rejection, if such insulators are later found to be defective.

45.6.2 IDENTIFICATION / MARKING:

45.6.2.1 Each unit of insulator shall be legibly and indelibly marked with the trade mark of the supplier, the year of manufacture, the guaranteed combined mechanical and electrical strength in kilo-newtons abbreviated by „KN" to facilitate easy identification and proper use.

45.6.2.2 The marking shall be on porcelain for porcelain insulators. The marking shall be printed and not impressed and the same shall be applied before firing.

45.7. QUALITY ASSURANCE PLAN:

45.7.1 The bidder hereunder shall invariably furnish following information along with his offer, failing which the offer shall be liable for rejection.

i. Statement giving list of important raw materials, names of sub-suppliers for the raw materials, list of standards according to which the raw material are tested, list of tests normally carried out on raw materials in presence of bidder's representative, copies of test certificates.

ii. Information and copies of test certificates as in (i) above in respect of bought out materials.

iii List of manufacturing facilities available.

iv Level of automation achieved and lists of area where manual processing exists.

v List of areas in manufacturing process, where stage inspections are normally carried out in quality control and details of such tests and inspection.

vi Special features provided in the equipment to make it maintenance free.

vii. List of testing equipping available with the bidder for final testing of equipment specified and test plant limitation, if any, vis-à-vis the type, special, acceptance and routine tests specified in the relevant standards. These limitations shall be very clearly brought out in schedule of deviations from specified test requirements.

45.7.2 The supplier shall within 30 days of placement of order submit the following information to the owner.

i) List of raw material and the names of sub-suppliers selected from those furnished along with the offer

Sl No	Description	EMS value	No of Discs	Size of Disc (mm)	CD of Disc (mm)	No of PLRI	Size of PLRI (mm)	CD of PLRI (mm)
1	132kV Single Suspension string	70/90KN – Normal	1 X 9	255 x 145	320	1 X 1	1305	2628
2	132kV Double Suspension string	70/90KN – Normal	2 X 9	255 x 145	320	2 X 1	1305	2628
3	132kV Single Suspension string	70/90KN – Anti Fog	1 X 9	255 x 145	430	1 X 1	1305	3625
4	132kV Double Suspension string	70/90KN – Anti Fog	2 X 9	255 x 145	430	2 X 1	1305	3625
5	132kV Single Suspension string	120KN – Anti Fog	1 X 10	280 x 145	430	1 X 1	1450	3625
6	132kV Double Suspension string	120KN – Anti Fog	2 X10	280 x 145	430	2 X 1	1450	3625
7	132kV Single Tension string	160KN – Anti Fog	1 X 10	305 x 170	475	1 X 1	1700	3625
8	132kV Double Tension string	160KN – Anti Fog	2 X10	305 X 170	475	2 X 1	1700	3625
9	220kV Single Suspension string	90KN – Normal	1 X 14	255 x 145	320	1 X 2	2030	4088
10	220kV Double Suspension string	90KN – Normal	2 X 14	255 x 145	320	2 X 2	2030	4088
11	220kV Single Suspension string	90KN – Anti Fog	1 X 14	255 x 145	430	1 X 2	2030	4380
12	220kV Double Suspension string	90KN – Anti Fog	2 X 14	255 x 145	430	2 X 2	2030	4380
13	220kV Single Suspension string	120KN – Anti Fog	1 X 15	280 x 145	430	1 X 2	2175	5180
14	220kV Double Suspension string	120KN – Anti Fog	2 X15	280 x 145	430	2 X 2	2175	5180
15	220kV Single Tension string	160KN – Anti Fog	1 X 15	305 x 170	475	1 X 2	2550	5550
16	220kV Double Tension string	160KN – Anti Fog	2 X15	305 X 170	475	2 X 2	2550	5550

Sl No	**Description**	**EMS value**	**No of Discs**	**Size of Disc (mm)**	**CD of Disc (mm)**	**No of PLRI**	**Size of PLRI (mm)**	**CD of PLRI (mm)**
17	400kV Single Suspension string	120KN – Anti Fog	1 X 25	280 x 145	430	1 X 3	3335	9200
18	400kV Double Suspension string	120KN – Anti Fog	2 X25	280 x 145	430	2 X 3	3335	9200
19	400kV Single Tension string	160KN – Anti Fog	1 X 25	305 x 170	475	1 X 3	3910	9200
20	400kV Double Tension string	160KN – Anti Fog	2 X25	305 X 170	475	2 X 3	3910	9200

Line Voltage	S/C or D/C	Nominal Span (E/W & Conductors in mtrs.)	Wind Zone as per IS 802	Design Tension at Every Day Temp (32º C) and full wind condition	Wind Pressure (kg/Sq-m) considering gust factor	Max Sag – Ground Wire at 53ºC (in mtrs)	UTS – Earthwire (in Kg)	Weight – Earth wire (in Kg/km)	Minimum Clearance in mtrs.		
									A1	B1	C1

APPENDIX-A

Table A-1

Typical transmission line details(To be filled by the Bidder)

				– Earthwire) in kg							
400KV	S/C										
	D/C										
220 KV	S/C										
	D/C										
132 KV	S/C										
	D/C										

A1 Minimum clearance between conductor and ground (in meters)

B1 Minimum clearance between two phase conductors (in meters) – vertical in case of D/C towers and horizontal in case of S/C towers.

C1 Minimum clearance between conductor and earth wire (in meters)

CHAPTER 46: TECHNICAL SPECIFICATION FOR OPTICAL GROUND WIRE (OPGW)

46.1. FIBRE OPTIC CABLES PARTICULAR SPECIFICATIONS (OPGW AND APPROACH CABLES)

46.1.1 OVERVIEW AND GENERAL REQUIREMENTS

OPGW and approach cables are required to provide:

- ➢Ground/earth shielding of the 132KV/220KV/400 KV new lines under this project and
- ➢Use the OPGW/Approach fibre component to the new 132KV/220KV/400KV grid substations of AEGCL to the existing Fibre Optic Network that can support grid communications with SLDC. The proposed augmentation will enable integration of SAS of the grid substations to SLDC. The new Fibre Optic Network will also enable transmission of Tele-protection and Tele-control Signalling; other Data transfer, Voice/Telephony and an Energy Management (EMS) System as fibre media-based functions of its grid communications network and enhanced operation and maintenance of Assam's transmission system and also non power utility communications.

46.1.2 STANDARDS

The following standards and codes shall be generally applicable to the equipment and Works supplied under this Contract:

(1) American Society for Testing and Materials ASTM-B415, ASTM-D1248, ASTM D3349.

(2) ITU-T/CCITT Recommendations G.650, G.652, G.653, G.655.

(3) Institute of Electrical and Electronics Engineers IEEE-812, 1138-1994, IEEE-524, IEEE-828 & 830 and latest amendment of IEEE 1138.

(4) Electronic Industries Association, EIA-455-3, 455-25A, 455-31B, 455-32, , 455-41, 455-91, 455-78, 455- 59, 455-80, 455-81, 455-169, 455-81, EIA RS 598

(5) International Electro technical Commission standards, IEC -1396 and IEC - 1089.

(6) International Electro technical Commission standards, IEC 61395, IEC 793-1, 793-2, 794-1, 794-2, IEC-529, IEC 60794-1-2, IEC 60794-4-10.

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 Bidder shall attempt to comply with such, provided that no additional expenses are charged to the Owner without Owner's written consent.

In addition, and particular recognition of this Contract's purpose to deliver a Fibre based power utility grid operation communication network the following reference documents are to be made available to the Employer its Project Manager and there content reflected as appropriate in the Contractor's Facilities detailed engineering design and implementation programme. These additional reference documents are:

i. CIGRE Guide for Planning of Power Utility Digital Communications Networks

ii. CIGRE Optical Fibre Planning Guide for Power Utilities

iii. CIGRE New Opportunities for Optical Fibre Technology in Electricity Utilities

iv CIGRE guide to fittings for Optical Cables on Transmission Lines.

46.1.3 BASIC TECHNICAL DATA

46.1.3.1 Site and Service Conditions

The OPGW and the Communication Equipment covered under this Contract are to run entirely within the State of Assam, India and shall be suitable for the topical climatic conditions prevailing in the Project areas as mentioned in chapter 2 of this bidding document.

46.1.3.2 Fibre optic cabling

The OPGW shall have 96 nos. optical fibres. The OPGW cable, associated hardware and fittings shall meet the requirements of G.652D Dual-window Single mode (DWSM) telecommunications grade fibre optic cable. All optical fibre cabling including fibre itself and all associated installation hardware shall have a minimum guaranteed design life span of 25 years. Documentary evidence in support of guaranteed life span of cable & fibre shall be submitted by the Contractor during detailed engineering.

46.1.3.3 Required optical fibre characteristics

The optical fibre to be provided should have following characteristics.

46.1.3.4 Required Optical Fibre Characteristics

The optical fibre to be provided should have following characteristic.

46.1.3.5 Physical Characteristic

Dual-Window Single mode (DWSM), G.652D optical fibres shall be provided in the fibre optic cables. DWSM optical fibres shall meet the requirements defined in Table 1-1(a).

46.1.3.6 Attenuation

The attenuation coefficient for wavelengths between 1525 nm and 1575 nm shall not exceed the attenuation coefficient at 1550 nm by more than 0.05 dB/km. The attenuation coefficient between 1285 nm and 1330 nm shall not exceed the attenuation coefficient at 1310 nm by more than 0.05 dB/km. The attenuation of the fibre shall be distributed uniformly throughout its length such that there are no point discontinuities in excess of 0.10 dB. The fibre attenuation characteristics specified in table 1-1 (a) shall be “guaranteed” fibre attenuation of any & every fibre reel.

The overall optical fibre path attenuation shall not be more than calculated below:

Maximum attenuation @ 1550nm: 0.21 dB/km x total km + 0.05 dB/splice x no. of splices + 0.5 dB/connector x no. of connectors.

Maximum attenuation @ 1310nm: 0.35dB/km x total km + 0.05 dB/splice x no. of splices + 0.5 dB/connector x no. of connectors.

Table-1

DWSM Optical Fibre Characteristics

Fibre Description:	Dual-Window Single-Mode
Mode Field Diameter:	8.6 to 9.5 µm (± 0.6 µm)
Cladding Diameter:	125.0 µm ± 1 µm

Mode field concentricity error	≤ 0.6μm
Cladding non-circularity	≤ 1%
Cable Cut-off Wavelength lcc	≤ 1260 nm
1550 nm loss performance	As per ITU-T G.652 D
Proof Test Level	≥ 0.69 Gpa
Attenuation Coefficient:	@ 1310 nm ≤ 0.35 dB/km @ 1550 nm ≤0.21 dB/km
Chromatic Dispersion; Maximum: **Zero Dispersion Wavelength:** **Zero Dispersion Slope:**	18 ps/(nm x km) @ 1550 nm 3.5 ps/(nm x km) 1288-1339nm 5.3 ps/(nm x km) 1271-1360nm 1300 to 1324nm 0.092 ps/nm^{2}xkm maximum
Polarization mode dispersion coefficient	≤0.2 ps/km$^{\lambda 1/2}$
Temperature Dependence:	Induced attenuation £ 0.05 dB (-60°C - +85°C)
Bend Performance:	@ 1310 nm (75±2 mm dia Mandrel), 100 turns; Attenuation Rise ≤ 0.05 dB @ 1550 nm (30±1 mm radius Mandrel), 100 turns; Attenuation Rise ≤ 0.05 dB @ 1550 nm (32±0.5 mm dia Mandrel, 1 turn; Attenuation Rise ≤ 0.50 dB

46.1.3.7 Fibre Optic Cable Construction

The OPGW (Optical Ground Wire) cable is proposed to be installed on the EHV transmission lines. The design of cable shall account for the varying operating and environmental conditions that the cable shall experience while in service. The OPGW cable to be supplied shall be designed to meet the overall requirements of all the transmission lines.

46.1.3.8 Optical Fibre Cable Link Lengths

The estimated optical fibre link lengths are provided in Appendices/Section Project/BoQ as transmission line route length. However, the Contractor shall supply & install the optical fibre cable as required based on detailed site survey to be carried out by the Contractor during the project execution. The Contractor shall verify the transmission line route length during the survey and the Contract price shall be adjusted accordingly.

For the purpose of payment, the optical fibre link lengths are defined as transmission line route lengths from Gantry at one terminating station to the Gantry in the other terminating station. The actual cable lengths to be delivered shall take into account various factors such as sag, service loops, splicing, working lengths & wastage etc. and no additional payment shall be payable in this regard. The unit rate for FO cable quoted in the Bid price Schedules shall take into account all such factors.

46.1.3.9 Optical Fibre Identification

Individual optical fibres within a fibre unit and fibre units shall be identifiable in accordance with EIA/TIA 598 or IEC 60304 or Bellcore GR-20 colour-coding scheme.

Colouring utilized for colour coding optical fibres shall be integrated into the fibre coating and shall be homogenous. The colour shall not bleed from one fibre to another and shall not fade during fibre preparation for termination or splicing.

Each cable shall have traceability of each fibre back to the original fibre manufacturer's fibre number and parameters of the fibre. If more than the specified number of fibres is included in any cable, the spare fibres shall be tested by the cable manufacturer and any defective fibres shall be suitably bundled, tagged and identified at the factory by the vendor.

46.1.3.10 Buffer Tube

Loose tube construction shall be implemented. The individually coated optical fibre(s) shall be surrounded by a buffer for protection from physical damage during fabrication, installation and operation of the cable. The fibre coating and buffer shall be strippable for splicing and termination. Each fibre unit shall be individually identifiable utilizing colour coding. Buffer tubes shall be filled with a water-blocking gel.

46.1.3.11 Optical Fibre Strain & Sag-Tension chart

The OPGW cable shall be designed and installed such that the optical fibres experience no strain under all loading conditions defined in IS 802. Zero fibre strain condition shall apply even after a 25-year cable creep.

For the purpose of this specification, the following definitions shall apply:

- Maximum Working Tension (MWT) is defined as the maximum cable tension at which there is no fibre strain.
- The no fibre strain condition is defined as fibre strain of less than or equal to 0.05%, as determined by direct measurements through IEC/ ETSI (FOTP) specified optical reflectometry
- The Cable strain margin is defined as the maximum cable strain at which there is no fibre strain.
- The cable Maximum Allowable Tension (MAT) is defined as the maximum tension experienced by the Cable under the worst case loading condition.
- The cable max strain is defined as the maximum strain experienced by the Cable under the worst-case loading condition.
- The cable Every Day Tension (EDT) is defined as the maximum cable tension on any span under normal conditions.
- The Ultimate /Rated Tensile Strength (UTS/ RTS/ breaking strength) is defined as the maximum tensile load applied and held constant for one minute at which the specimen shall not break. While preparing the Sag-tension charts for the OPGW cable the following conditions shall be met:
- The Max Allowable Tension (MAT) / max strain shall be less than or equal to the MWT/ Strain margin of the cable.
- The sag shall not exceed the earth wire sag in all conditions.
- The Max Allowable Tension shall also be less than or equal to 0.4 times the UTS.

- The 25-year creep at 25% of UTS (creep test as per IEEE 1138) shall be such that the 25 year creep plus the cable strain at Max Allowable Tension (MAT) is less than or equal to the cable strain margin.
- The everyday tension (EDT) shall not exceed 20% of the UTS for the OPGW cable.

The Sag-tension chart of OPGW cable indicating the maximum tension, cable strain and sag shall be calculated and submitted along with the bid under various conditions mentioned below:

1. 53° C , no wind and no ice
2. 32° C, no wind and no ice
3. 0°C, no wind and no ice
4. 32° C, full wind and no ice
5. 32° C, 75% full wind and no ice
6. 0° C, 2/3rd / 36% of full wind (IS 802:1977/1995)

The above cases shall be considered for the spans from 100 m to max. span length in the range of 50 m spans. Max. Vertical sag, max. tension and max sag at 0° C & no wind shall be considered in line with the design parameter of transmission line. The typical details are indicated in the Appendix A. The full wind load shall be considered as the design wind load for all the specified transmission lines as per relevant IS 802 version and the sag-tension chart shall be submitted considering the transmission lines.

46.1.3.12 Cable Materials

The materials used for optical fibre cable construction, shall meet the following requirements:

46.1.3.13 Filling Materials

The interstices of the fibre optic unit and cable shall be filled with a suitable compound to prohibiting moisture ingress or any water longitudinal migration within the fibre optic unit or along the fibre optic cable. The water tightness of the cable shall meet or exceed the test performance criteria as per IEC 60794-1-F-5.

The filling compound used shall be a non-toxic homogenous waterproofing compound that is free of dirt and foreign matter, non-hygroscopic, electrically nonconductive and non-nutritive to fungus. The compound shall also be fully compatible with all cable components it may come in contact with and shall inhibit the generation of hydrogen within the cable.

The waterproofing filling materials shall not affect fibre coating, colour coding, or encapsulant commonly used in splice enclosures, shall be dermatologically safe, non-staining and easily removable with a non-toxic cleaning solvent.

46.1.3.14 Metallic Members

When the fibre optic cable design incorporates metallic elements in its construction, all metallic elements shall be electrically continuous.

46.1.3.15 Marking, Packaging and Shipping

This section describes the requirements for marking, packaging and shipping the overhead fibre optic cable.

(a) Drum Markings: Each side of every reel of cable shall be permanently marked in white lettering with the vendors' address, the Purchaser's destination address, cable part number and specification as to the type of cable, length, number of fibres, a unique drum number including the name of the transmission line & segment no., factory inspection stamp and date.

(b) Cable Drums: All optical fibre cabling shall be supplied on strong drums provided with lagging of adequate strength, constructed to protect the cabling against all damage and displacement during transit, storage and subsequent handling during installation. Both ends of the cable shall be sealed as to prevent the escape of filling compounds and dust & moisture ingress during shipment and handling. Spare cable caps shall be provided with each drum as required.

The spare cable shall be supplied on sturdy, corrosion resistant, steel drums suitable for long periods of storage and re-transport & handling.

There shall be no factory splices allowed within a continuous length of cable. Only one continuous cable length shall be provided on each drum. The lengths of cable to be supplied on each drum shall be determined by a "schedule" prepared by the Contractor and approved by the owner.

46.1.3.16 Optical Ground Wire (OPGW)

OPGW cable construction shall comply with IEEE-1138, 2009. The cable provided shall meet both the construction and performance requirements such that the ground wire function, the optical fibre integrity and optical transmission characteristics are suitable for the intended purpose. The cable shall consist of optical fibre units as defined in this specification. There shall be no factory splices within the cable structure of a continuous cable length.

The composite fibre optic overhead ground wire shall be made up of multiple buffer tubes embedded in a water tight aluminium/aluminium alloy/stainless steel with aluminium coating protective central fibre optic unit surrounded by concentric-lay stranded metallic wires in single or multiple layers. Each buffer tube shall have maximum 12 no. of fibres. All fibres in single buffer tube or directly in central fibre optic unit is not acceptable. The dual purpose of the composite cable is to provide the electrical and physical characteristics of conventional overhead ground wire while providing the optical transmission properties of optical fibre.

46.1.3.17 Central Fibre Optic Unit

The central fibre optic unit shall be designed to house and protect multiple buffered optical fibre units from damage due to forces such as crushing, bending, twisting, tensile stress and moisture. The central fibre optic unit and the outer stranded metallic conductors shall serve together as an integral unit to protect the optical fibres from degradation due to vibration and galloping, wind and ice loadings, wide temperature variations, lightning and fault current, as well as environmental effects which may produce hydrogen.

The OPGW design of dissimilar materials such as stainless-steel tube with aluminium or aluminium–clad-steel wire strands are not allowed. Central fibre optic unit may be of aluminium or stainless-steel tube with aluminium protective coating. In case of aluminium protective coating, the coating must completely cover the tubes leaving no exposed areas of tubing that can make electrical contact either directly or indirectly through moisture, contamination, protrusions, etc with the surrounding stranded wires. The tube may be fabricated as a seamless tube, seam welded, or a tube without a welded seam.

Transmission Line Voltage and Wind Zone	OPGW Cable Parameters						
	UTS (kg)	Area (sqmm)	Wt (Kg/m)	Dia (mm)	Modulus of Elasticity (Kg/sqmm)	Coeff of Linear Expansion (per deg c)	Central Fibre Optic Unit Design
400kV M/C WZ 1-4 400kV D/C WZ 1-5	9350±150	56.5±2.5	0.45±0.01	12±0.2	14290±110	0.0000138±0.0000003	Al tube
220kV D/C WZ 1-4 132kV D/C WZ 1-5	7376±50	51±2	0.355±0.01	11.4±0.2	12344±100	0.0000149±0.0000003	Al Tube
River Crossing Section	20059±100	118±5	0.884±0.01	14.7±0.2	16355±100	0.0000127±0.0000003	Stainless Steel Tube

Table: OPGW Parameters to be considered for different line voltage and wind zone

46.1.3.18 Basic Construction

The OPGW cable construction shall conform to the applicable requirements of this specification, applicable clauses of IEC 61089 related to stranded conductors and Table 1.2(a) OPGW Mechanical and Electrical Characteristics. In addition, the basic construction shall include bare concentric-lay-stranded metallic wires with the outer layer having left hand lay. The wires may be of multiple layers with a combination of various metallic wires within each layer. The direction of lay for each successive layer shall be reversed. The finished wires shall contain no joints or splices unless otherwise agreed to by the Employer and shall conform to all applicable clauses of IEC 61089 as they pertain to stranded conductors.

The wires shall be so stranded that when the complete OPGW is cut, the individual wires can be readily regrouped and then held in place by one hand.

46.1.3.19 Breaking Strength

The rated breaking strength of the completed OPGW shall be taken as no more than 90 percent of the sum of the rated breaking strengths of the individual wires, calculated from their nominal diameter and the specified minimum tensile strength.

The rated breaking strength shall not include the strength of the optical unit. The fibre optic unit shall not be considered a load bearing tension member when determining the total rated breaking strength of the composite conductor.

46.1.3.20 Electrical and Mechanical Requirements

Table 1-2(a) provides OPGW Electrical and Mechanical Requirements for the minimum performance characteristics. Additionally, the OPGW mechanical & electrical characteristics shall be similar to that of the earth wire being replaced such that there is no or minimal consequential increase in stresses on towers. For the purposes of determining the appropriate Max Working Tension limit for the OPGW cable IS 802:1995 and IS 875: 1987 shall be applied. However, the OPGW installation sag & tension charts shall be based on IS 802 version to which the line is originally designed. For the OPGW cable design selection and preparation of sag tension charts, the limits specified in this section shall also be satisfied. The Bidder shall submit sag-tension charts for the above cases with their bids.

Table 1.2(a)

OPGW Electrical and Mechanical Requirements

(1)	**Everyday Tension**	≤20% of UTS of OPGW
(2)	**D.C. Resistance at 20ºC:**	< 1.0 ohm/Km
(3)	**Short Circuit Current**	≥ 6.32 kA for 1.0 second

46.1.3.21Operating conditions

Since OPGW shall be located at the top of the transmission line support structure, it will be subjected to Aeolian vibration, Galloping and Lightning strikes. It will also carry ground fault currents. Therefore, its electrical and mechanical properties shall be same or similar as those required of conventional ground conductors.

46.1.3.22 Installation

OPGW installed under live line condition, i.e. with all circuits charged to the rated line voltage as specified in this section shall be generally in accordance with the IEEE Guide to the Installation of Overhead Transmission Line Conductors (IEEE STD. 524 with latest revisions), with additional instructions and precautions for live line working and fibre optic cable handling.

A tower structural analysis shall be carried out by the Contractor wherever required, based on the relevant data to be provided by Employer, to ensure that with the replacement of existing earth wire with the OPGW cable, the tower members remain within the statutory safety limits as per Indian Electricity rules and if required the Contractor shall carry out the tower strengthening as necessary at no additional cost to Employer. The OPGW cable sections shall normally be terminated & spliced only on tension towers. In exceptional circumstances, and on Employer specific approval, cable may be terminated on Suspension towers, but in this case tower strength shall be examined to ensure that tower loads are within safe limits and if required, necessary tower strengthening shall be carried out by the Contractor at no additional cost to Employer.

46.1.3.23Installation Hardware

The scope of supply includes all required fittings and hardware such as Tension assembly, Suspension assembly, Vibration dampers, reinforcing rods, Earthing clamps, Downlead clamps, splice enclosure etc. The Bidder shall provide documentation justifying the adequacy and suitability of the hardware supplied. The quantity of hardware & fittings to meet any eventuality during site installation minimum@ 1% shall also be provided as part of set/km for each transmission line without any additional cost to Employer. The OPGW hardware fittings and accessories shall follow the general requirements regarding design, materials, dimensions & tolerances, protection against corrosion and markings as specified in clause 4.0 of EN 61284: 1997 (IEC 61284). The shear strength of all bolts shall be at least 1.5 times the maximum installation torque. The OPGW hardware & accessories drawing & Data Requirement Sheets (DRS) document shall consist of three parts:

(1) A technical particular sheet

(2) An assembly drawing i.e. level 1 drawing and

(3) Component level drawings i.e. level 2 & lower drawings. All component reference numbers, dimensions and tolerances, bolt tightening torques & shear strength and ratings such as UTS, slip strength etc shall be marked on the drawings.

The fittings and accessories described herein are indicative of installation hardware typically used for OPGW installations and shall not necessarily be limited to the following:

(a) Suspension Assemblies: Preformed armour grip suspension clamps and aluminium alloy armour rods/ reinforcing rods shall be used. The suspension clamps shall be designed to carry a vertical load of not less than 25 KN. The suspension clamps slippage shall occur between 12kN and 17 kN as measured. The Contractor shall supply all the components of the suspension assembly including shackles, bolts, nuts, washers, split pins, etc. The total drop of the suspension assembly shall not exceed 150 mm (measured from the centre point of attachment to the centre point of the OPGW). The design of the assembly shall be such that the direction of run of the OPGW shall be the same as that of the conductor.

(b) Dead End Clamp Assemblies: All dead-end clamp assemblies shall preferably be of performed armoured grip type and shall include all necessary hardware for attaching the assembly to the tower strain plates. Dead end clamps shall allow the OPGW to pass through continuously without cable cutting. The slip strength shall be rated not less than 95% of the rated tensile strength of the OPGW.

(c) Clamp Assembly Earthing Wire: Earthing wire consisting of a 1500 mm length of aluminium or aluminium alloy conductor equivalent in size to the OPGW shall be used to earth suspension and dead-end clamp assemblies to the tower structure. The earthing wire shall be permanently fitted with lugs at each end. The lugs shall be attached to the clamp assembly at one end and the tower structure at the other.

(d) Structure Attachment Clamp Assemblies: Clamp assemblies used to attach the OPGW to the structures, shall have two parallel grooves for the OPGW, one on either side of the connecting bolt. The clamps shall be such that clamping characteristics do not alter adversely when only one OPGW is installed. The tower attachment plates shall locate the OPGW on the inside of the tower and shall be attached directly to the tower legs/cross-members without drilling or any other structural modifications.

(e) Vibration Dampers: Vibration dampers type 4R Stockbridge or equivalent, having four (4) different frequencies spread within the Aeolian frequency bandwidth corresponding to wind speed of 1m/s to 7 m/s, shall be used for suspension and tension points in each span. The Contractor shall determine the exact numbers and placement(s) of vibration dampers through a detailed vibration analysis as specified in technical specifications.

One damper minimum on each side per OPGW cable for suspension points and two dampers minimum on each side per OPGW cable for tension points shall be used for nominal design span of 400 meters. For all other ruling spans, the number of vibration damper shall be based on vibration analysis.

The clamp of the vibration damper shall be made of high strength aluminium alloy of type LM-6. It shall be capable of supporting the damper and prevent damage or chaffing of the conductor during erection or continued operation. The clamp shall have smooth and permanent grip to keep the damper in position on the OPGW cable without damaging the strands or causing premature fatigue failure of the OPGW cable under the clamp. The clamp groove shall be in uniform contact with the OPGW cable over the entire clamping surface except for the rounded edges. The groove of the clamp body and clamp cap shall be smooth, free from projections, grit or other materials which could cause damage to the OPGW cable when the clamp is installed. Clamping bolts shall be provided with self locking nuts and designed to prevent corrosion of threads or loosening in service.

The messenger cable shall be made of high strength galvanised steel/stain less steel. It shall be of preformed and post formed quality in order to prevent subsequent droop of weight and to maintain consistent flexural stiffness of the cable in service. The messenger cable other than stainless steel shall be hot dip galvanised in accordance with the recommendations of IS:4826 for heavily coated wires.

The damper mass shall be made of hot dip galvanised mild steel/cast iron or a permanent mould cast zinc alloy. All castings shall be free from defects such as cracks, shrinkage, inclusions and blow holes etc. The surface of the damper masses shall be smooth.

The damper clamp shall be casted over the messenger cable and offer sufficient and permanent grip on it. The messenger cable shall not slip out of the grip at a load less than the mass pull-off value of the damper. The damper masses made of material other than zinc alloy shall be fixed to the messenger cable in a suitable manner in order to avoid excessive stress concentration on the messenger cables which shall cause premature fatigue failure of the same. The messenger cable ends shall be suitably and effectively sealed to prevent corrosion. The damper mass made of zinc alloy shall be casted over the messenger cable and have sufficient and permanent grip on the messenger cable under all service conditions. The contractor must indicate the clamp bolt tightening torque to ensure that the slip strength of the clamp is maintained between 2.5 kN and 5 kN. The clamp when installed on the OPGW cable shall not cause excessive stress concentration on the OPGW cable leading to permanent deformation of the OPGW strands and premature fatigue failure in operation. The vibration analysis of the system, with and without damper and dynamic characteristics of the damper as detailed in Technical Specification, shall have to be submitted. The technical particulars for vibration analysis and damping design of the system are as follows

Sl No	Description	Technical Particulars
1	Span Length in meters (i) Ruling design span: (ii) Maximum span: (iii) Minimum Span:	 400 meters 1100 meters 100 meters
2	Configuration:	As per Specifications
3	Tensile load in each:	As per sag tension calculations
4	Armour rods used:	Standard preformed armour rods/AGS
5	Maximum permissible dynamic strain:	+/- 150 micro strains

The damper placement chart for spans ranging from 100m to 1100m shall be submitted by the Contractor.

Placement charts should be duly supported with relevant technical documents and sample calculations.

The damper placement charts shall include the following

(1) Location of the dampers for various combinations of spans and line tensions clearly indicating the number of dampers to be installed per OPGW cable per span.

(2) Placement distances clearly identifying the extremities between which the distances are to be measured.

(3) Placement recommendation depending upon type of suspension clamps (viz Free center type/Armour grip type etc.)

(4) The influence of mid span compression joints, repair sleeves and armour rods (standard and AGS) in the placement of dampers.

46.1.3.24 Fibre Optic Splice Enclosures (Joint Box)

All splices shall be encased in Fibre Optic Splice Enclosures. Suitable splice enclosures shall be provided to encase the optical cable splices in protective, moisture and dust free environment. Splice enclosures shall comply with ingress protection class IP 66 or better. The splice enclosures shall be designed for the storage and protection of required number of optical fibre splices and equipped with sufficient number of splice trays for splicing all fibres in the cable. No more than 12 fibres shall be terminated in a single splice tray. They shall be filled with suitable encapsulate that is easily removable should re-entry be required into the enclosures. Splice enclosures shall be suitable for outdoor use with each of the cable types provided under this contract. Splice enclosures shall be appropriate for mounting on transmission line towers above anticlimb guard levels at about 10 metres from top of the tower and shall accommodate pass-through splicing. The actual mounting height and location shall be finalised after Survey. Contractor shall be responsible for splicing of fibres and installation of splice enclosures.

46.1.3.25 Optical Fibre Splices

Splicing of the optical fibre cabling shall be minimized through careful Contractor planning. There shall be no mid-span splices allowed. All required splices shall be planned to occur on tower structures. All optical fibre splicing shall comply with the following:

(a) All fibre splices shall be accomplished through fusion splicing.

(b) Each fibre splice shall be fitted with a splice protection sheath fitted over the final splice.

(c) All splices and bare fibre shall be neatly installed in covered splice trays.

(d) For each link, bi-directional attenuation of single mode fusion splices, shall not average more

than 0.05 dB and no single splice loss shall exceed 0.1 dB when measured at 1550 nm.

(e) For splicing, fibre optic cable service loops of adequate length shall be provided so that all splices occurring at tower structures can be performed at ground level.

46.1.3.26 Fibre Optic Approach Cables

For purposes of this specification, a fibre optic approach cable is defined as the Armoured underground fibre optic cable required to connect Overhead Fibre Optic Cable (OPGW) between the final in line splice enclosure on the gantry / tower forming the termination of the fibre cable on the power line and the Fibre Optic Distribution Panel (FODP) installed within the building. The estimated fibre optic approach cabling length requirements are indicated in the appendices/BoQ. However, the Contractor shall supply & install the optical fibre approach cable as required based on detailed site survey to be carried out by the Contractor during the project execution and the Contract price shall be adjusted accordingly.

46.1.3.27 Basic Construction

The cable shall be suitable for direct burial, laying in trenches & PVC/Hume ducts, laying under false flooring and on indoor or outdoor cable raceways.

46.1.3.28 Jacket Construction & Material

The Approach Cable shall be a UV resistant, rodent proof, armoured cable with metallic type of armouring. The outer cable jacket for approach cable shall consist of carbon black polyethylene resin to prevent damage from exposure to ultra-violet light, weathering and high levels of pollution. The jacket shall conform to ASTM D1248 for density.

46.1.3.29 Optical, Electrical and Mechanical Requirements

Approach cable shall contain fibres with identical optical/ physical characteristics as those in the OPGW cables. The cable core shall comprise of tensile strength member(s), fibre support/bedding structure, core wrap/bedding, and an overall impervious jacket.

46.1.4.0 Fibre Optic Distribution Panel

Fibre Optic Distribution Panels is required for each location for termination of fibres in a manner consistent with the following:

(a) FODPs shall be suitable for use with each of the cable types provided as part of this contract. FODPs shall accommodate pass-through splicing and fibre terminations.

(b) FODPs for indoor use shall be supplied in suitable cabinets/racks with locking arrangement

(c) All FODPs shall be of corrosion resistant, robust construction and shall allow both top or bottom entry for access to the splice trays. Ground lugs shall be provided on all FODPs and the Contractor shall ensure that all FODPs are properly grounded. The FODP shall meet or exceed ingress protection class IP55 specifications.

46.1.5.0 Optical Fibre Connectors

Optical fibres shall be connectorised with FC-PC type connectors preferably. Alternatively, connector with matching patch cord shall also be acceptable. Fibre optic couplings supplied with FODPs shall be appropriate for the fibre connectors to be supported. There shall be no adapters.

46.1.5.1 Service Loops

For purposes of this specification, cable and fibre service loops are defined as slack (extra) cable and fibre provided for facilitating the installation, maintenance and repair of the optical fibre cable plant.

(a) Outdoor Cable Service Loops: In-line splice enclosures installed outdoors and mounted on the utility towers shall be installed with sufficient fibre optic cable service loops such that the recommended minimum bend radius is maintained while allowing for installation or maintenance of the cable to be performed in a controlled environment at ground level.

(b) Indoor Cable Service Loops: FODPs shall provide at least three (3) metres of cable service loop. Service loops shall be neatly secured and stored, coiled such that the minimum recommended bend radius' are maintained.

(c) Fibre Units Service Loops: For all fibre optic cable splicing, the cable shall be stripped back a sufficient length such that the fan-out of fibre units shall provide for at least one (1) metre of fibre unit service loop between the stripped cable and the bare fibre fan-out.

(d) Pigtail Service Loops : Connectorised pigtails spliced to bare fibres shall provide at least 1 metre of service loop installed in the FODP fibre organizer and at least one (1) metre of service loop to the couplings neatly stored behind the FODP coupling panels.

(e) Fibre Service Loops : At least 0.5 metre of bare fibre service loop shall be provided on each side of all fibre splices. The bare fibre service loops shall be neatly and safely installed inside covered splice trays.

46.1.6.0 Test Equipment

Appendix-B provides mandatory test equipment requirements, to be provided. The parameters / features of the mandatory equipment are enumerated in Table 1.3 below and Chapter “ Spares and Tools”

Table 1.3

Sl No	Test Equipment	
A.	Test Equipment for OPGW cable	
1	OTDR (Optical Time Domain Reflectometer) for 1310/1550 nm	
2	Optical Attenuators (variable 1310/1550nm).	
3	Optical Power meter (1310/1550nm)	
4	Laser Light Source (1310/1550nm)	
5	Optical Fibre Fusion Splicer incl. Fibre cleaver etc	
6	OFC Tool kit consisting of Fibre stripping tool and tools for cutting and stripping of sheathing, jacket armouring of OFAC/ADSS/OPGW cables including two nos of high resolution hand held Binoculars	
7	Optical test accessory kit including all Necessary connectors, adaptors, cables, terminations and other items required for testing	

In case the offered make/model of test equipment has multiple options for the parameters, the option of higher range shall be acceptable. The supplied test equipment shall be suitable for use in the high EMI/EMC environment. The Contractor shall submit performance certificate for offered test equipment from at least one customer.

46.1.7.0 Inspection & Testing Requirement

All materials furnished and all work performed under this Contract shall be inspected and tested. Deliverables shall not be shipped until all required inspections and tests have been completed, and all deficiencies have been corrected to comply with this Specification and approved for shipment by the Employer.

Except where otherwise specified, the Contractor shall provide all manpower and materials for tests, including testing facilities, logistics, power and instrumentation, and replacement of damaged parts. The costs shall be borne by the Contractor and shall be deemed to be included in the contract price.

The entire cost of testing for factory, production tests and other test during manufacture specified herein shall be treated as included in the quoted unit price of materials, except for the expenses of Inspector/Employer’s representative.

Acceptance or waiver of tests shall not relieve the Contractor from the responsibility to furnish material in accordance with the specifications.

All tests shall be witnessed by the Employer and/or its authorized representative (hereinafter referred to as the Employer) unless the Employer authorizes testing to proceed without witness. The Employer representative shall sign the test form indicating approval of successful tests.

Should any inspections or tests indicate that specific item does not meet Specification requirements, the appropriate items shall be replaced, upgraded, or added by the Contractor as necessary to correct the noted deficiencies at no cost to the Employer. After correction of a deficiency, all necessary retests shall be performed to verify the effectiveness of the corrective action.

The Employer reserves the right to require the Contractor to perform, at the Employer's expense, any other reasonable test(s) at the Contractor's premises, on site, or elsewhere in addition to the specified Type, Acceptance, Routine, or Manufacturing tests to assure the Employer of specification compliance.

46.1.8.0 Testing Requirements

Following are the requirements of testing :

1. Type Testing
2. Factory Acceptance Testing
3. Site Acceptance Testing

46.1.9.0 Type Testing

"Type Tests" shall be defined as those tests which are to be carried out to prove the design, process of manufacture and general conformity of the materials to this Specification. Type Testing shall comply with the following:

(a) All cable & equipment being supplied shall conform to type tests as per technical specification.

(b)The test reports submitted shall be of the tests conducted within last seven (7) years for OPGW cable prior to the date of proposal/offer submitted. In case the test reports are older than seven (7) years for OPGW cable on the date of proposal/offer, the Contractor shall repeat these tests at no extra cost to the Employer.

(c) The Contractor shall submit, within 30 days of Contract Award, copies of test reports for all of the Type Tests that are specified in the specifications and that have previously (before Contract award) been performed. These reports may be accepted by the Employer only if they apply to materials and equipment that are essentially identical to those due to be delivered under the Contract and only if test procedures and parameter values are identical to those specified in this specifications carried out at accredited labs and witnessed by third party / customer’s representatives. In the event of any discrepancy in the test reports or any type tests not carried out, same shall be carried out by Contractor without any additional cost implication to the Employer.

In case the Type Test is required to be carried out, then following shall be applicable:-

(d) Type Tests shall be certified or performed by reputed laboratories using material and equipment data sheets and test procedures that have been approved by the Employer. The test procedures shall be formatted as defined in the technical specifications and shall include a complete list of the applicable reference standards and submitted for Employer approval at least four (4) weeks before commencement of test(s). The Contractor shall provide the Employer at least 30 days written notice of the planned commencement of each type test.

(e) The Contractor shall provide a detailed schedule for performing all specified type tests. These tests shall be performed in the presence of a representative of the Employer.

(f) The Contractor shall ensure that all type tests can be completed within the time schedule offered in his Technical Proposal.

In case of failure during any type test, the Supplier is either required to manufacture a fresh sample lot and repeat all type tests successfully or repeat that particular type test(s) at least three times successfully on the samples selected from the already manufactured lot at his own expenses. In case a fresh lot is manufactured for testing then the lot already manufactured shall be rejected.

46.1.9.1 Type Test Sample

The Contractor shall supply equipment/material for sample selection only after the Quality Assurance Plan has been approved by the Employer. The sample material shall be manufactured strictly in accordance with the approved Quality Assurance Plan. The Contractor shall submit for Employer approval, the type test sample selection procedure. The selection process for conducting the type tests shall ensure that samples are selected at random. For optical fibres/ Fibre Optic cables, at least three reels/ drums of each type of fibre/cable proposed shall be offered for selection. For FO cable installation hardware & fittings at least ten (10) samples shall be offered for selection. For Splice enclosures at least three samples shall be offered for selection.

46.1.9.2 List of Type Tests

The type testing shall be conducted on the following items

(a) Optical fibres

(b) OPGW Cable

(c) OPGW Cable fittings

(d) Vibration Damper

(e) Splice Enclosure (Joint Box)

(f) Approach Cable

46.1.9.3 Type Tests for Optical Fibres

The type tests listed below in table 2-1 shall be conducted on DWSM fibres to be supplied as part of overhead cables. The tests specific to the cable type are listed in subsequent sections.

SL. No.	Test Name	Acceptance Criteria	Test procedure
1	Attenuation	As per Section-01 of TS	IEC 60793-1-40Or EIA/TIA
2	Attenuation Variation with Wavelength		IEC 60793-1-40 Or EIA/TIA 455-78A
3	Attenuation at Water Peak		IEC 60793-1-40 Or EIA/TIA 455-78A
4	Temp. Cycling (Temp dependence of Attenuation)		IEC 60793-1-52 Or EIA/TIA 455-3A, 2 cycles
5	Attenuation With Bending(Bend Performance)		IEC 60793-1-47 Or EIA/TIA 455-62A
6	Mode Field dia.		IEC 60793-1-45 Or EIA/TIA 455-164A/167A/174
7	Chromatic Dispersion		IEC 60793-1-42 Or EIA/TIA 455-168A/169A/175A
8	Cladding Diameter		IEC 60793-1-20 OrEIA/TIA 455-176
9	Point Discontinuities of attenuation		IEC 60793-1-40 Or EIA/TIA 455-59
10	Core -Clad concentricity error		IEC 60793-1-20 OrEIA/TIA 455-176

11	Fibre Tensile Proof Testing		IEC 60793-1-30 Or EIA/TIA 455-31B

46.1.9.4 Type Tests for OPGW Cables

The type tests to be conducted on the OPGW cable are listed in Table 2-2 Type Tests for OPGW Cables. Unless specified otherwise in the technical specifications or the referenced standards, the optical attenuation of the specimen, measured during or after the test as applicable, shall not increase by more than 0.05 dB/Km.

S. No.	Test Name	Test Description	Test Procedure	
1	Water Ingress Test	IEEE 1138-2009	IEEE 1138-2009 (IEC 60794-1-2 Method F5 or EIA/TIA 455-82B) : Test duration : 24 hours	
2	Seepage of filling compound	IEEE 1138-2009	IEEE 1138-2009 (EIA/TIA 455-81B)	Preconditioning period:72 hours. Test duration: 24 hours.
3	Short Circuit Test	IEEE 1138-2009	IEEE 1138-2009	Fibre attenuation shall be continuously monitored and recorded through a digital data logging system or equivalent means. A suitable temperature sensor such as thermocouple shall be used to monitor and record the temperature inside the OPGW tube in addition to monitoring & recording the temperatures between the strands and between optical tube and the strand as required by IEEE 1138. Test shall be conducted with the tension clamps proposed to be supplied. The cable and the clamps shall be visually inspected for mechanical damage and photographed after the test.
		Or IEC60794-4-10 / IEC 60794-1-2 (2003) Method H1		Initial temperature during the test shall be greater than or equal to ambient field temperature.
4	Aeolian Vibration Test	IEEE 1138-2009 Or IEC60794 4-10 / IEC 60794-1-	IEEE 1138-2009	Fibre attenuation shall be continuously monitored and recorded through a digital data logging system or equivalent means. The vibration frequency and amplitude shall be monitored and recorded continuously. All

		2, Method E19		fibres of the test cable sample shall be spliced together in serial for attenuation monitoring. Test shall be conducted with the tension/suspension clamps proposed to be supplied. The cable and the clamps shall be visually inspected for mechanical damage and photographed
S. No.	**Test Name**	**Test Description**	**Test Procedure**	
5	Galloping test	EEE 1138-2009	IEEE 1138-2009	Test shall be conducted with the tension/suspension clamps proposed to be supplied. The cable and clamps shall be visually inspected for mechanical damage and photographed after the test. All fibres of the test cable sample shall be spliced together in serial for attenuation monitoring.
6	Cable Bend Test	Procedure 2 in IEC 60794-1-2 Method E11		The short-term and long-term bend tests shall be conducted in accordance with Procedure 2 in IEC 60794-1-2 E11 to determine the minimum acceptable radius of bending without any increase in attenuation or any other damage to the fibre optic cable core such as bird caging, deformation, kinking and crimping.
7	Sheave Test	IEEE 1138-2009 OR IEC 60794-1-2 (2003) Method E1B	IEEE 1138-2009	Fibre attenuation shall be continuously monitored and recorded through a digital data logging system or equivalent means. The Sheave dia. shall be based on the pulling angle and the minimum pulley dia employed during installation. All fibres of the test cable sample shall be spliced together in serial for attenuation monitoring.
8	Crush Test	IEEE 1138-2009	IEEE 1138-2009 (IEC 60794-1-2, Method E3/ EIA/TIA 455-41B)	The crush test shall be carried out on a sample of approximately one (1) metre long in accordance with IEC 60794-1-2 E3. A load equal to 1.3 times the weight of a 400-metre length of fibre optic cable shall be applied for a period of 10 minutes. A permanent or temporarily increase in optical attenuation value greater than 0.1 dB

				change in sample shall constitute failure. The load shall be further increased in small increments until the measured attenuation of the optical waveguide fibres increases and the failure load recorded along with results.
9	Impact Test	IEEE 1138-2009	IEEE 1138-2009, (IEC 60794-1-2 E4/ EIA/TIA 455-25B)	The impact test shall be carried out in accordance with IEC 60794-1-2 E4. Five separate impacts of 0.1- 0.3kgm shall be applied. The radius of the intermediate piece shall be the reel drum radius ± 10%. A permanent or temporary increase in optical attenuation value greater than 0.1 dB/km change in sample shall constitute failure.

S. No.	Test Name	Test Description	Test Procedure	
10	Creep Test	IEEE 1138-2009	IEEE 1138-2009	As per Aluminium Association Method, the best-fit straight line shall be fitted to the recorded creep data and shall be extrapolated to 25 years. The strain margin of the cable at the end of 25 years shall be calculated. The time when the creep shall achieve the strain margin limits shall also be calculated.
11	Fibre Strain Test	IEEE 1138-1994	IEEE 1138-1994	
12	Strain Margin Test	IEEE 1138-2009	IEEE 1138-2009	
13	Stress strain Test	IEEE 1138-2009	IEEE 1138-2009	
14	Cable Cut-off wavelength Test	IEEE 1138-1994	IEEE 1138-2009	
15	Temperature Cycling Test	IEEE 1138-2009	IEEE 1138-2009 Or IEC 60794-1-2, Method F1	
16	Corrosion (Salt Spray) Test	EIA/TIA 455-16A		
17	Tensile Performance Test	IEC 60794-1-2 E1 / EIA/TIA 455-33B	The test shall be conducted on a sample of sufficient length in accordance with IEC 60794-1-2 E1. The attenuation variation shall not exceed 0.05 dB/Km up to 90% of RTS of fibre optic cable. The load shall be increased at a steady rate up to rated tensile strength and held for one (1)	

			minute. The fibre optic cable sample shall not fail during the period. The applied load shall then be increased until the failing load is reached and the value recorded.
18	Lightning Test	IEC 60794-4-10 / IEC 60794-1-2 (2003)	The OPGW cable construction shall be tested in accordance with IEC 60794-1-2, Method H2 for Class 1.
19	DC Resistance Test (IEC 60228)	On a fibre optic cable sample of minimum 1 metre length, two contact clamps shall be fixed with a predetermined bolt torque. The resistance shall be measured by a Kelvin double bridge by placing the clamps initially zero metre and subsequently one metre apart. The tests shall be repeated at least five times and the average value recorded after correcting at 20°C.	

46.1.9.5 Type Test on OPGW Cable Fittings

The type tests to be conducted on the OPGW Cable fittings and accessories are listed below:

(i) Mechanical Strength Test for Suspension/Tension Assembly

Applicable Standards: IEC 61284, 1997.

Suspension Assembly

The armour rods /reinforcement rods are assembled on to the approved OPGW using the Installation Instructions to check that the assembly is correctly fitted and is the same that will be carried out during installations.

Part 1:

The suspension assembly shall be increased at a constant rate up to a load equal to 50% of the specified minimum Failure Load increased and held for one minute for the test rig to stabilise. The load shall then be increased at a steady rate to 67% of the minimum Failure Load and held for five minutes. The angle between the cable, the Suspension Assembly and the horizontal shall not exceed 16o. This load shall then be removed in a controlled manner and the Protection Splice disassembled. Examination of all the components shall be made and any evidence of visual deformation shall be documented.

Part 2:

The Suspension clamp shall then be placed in the testing machine. The tensile load shall gradually be increased up to 50% of the specified Minimum Failure Load of the Suspension Assembly and held for one minute for the Test Rig to stabilise and the load shall be further increased at a steady rate until the specified minimum Failure Load is reached and held for one minute. No fracture should occur during this period. The applied load shall then be increased until the failing load is reached and the value shall be documented.

Tension Assembly

The Tension Assembly is correctly fitted and is the same that will be carried out during installations.

Part 1:

The tension assembly (excluding tension clamp) shall be increased at a constant rate up to a load equal to 50% of the specified minimum Failure Load increased at a constant rate and held for one minute for the test rig to stabilise. The load shall then be increased at a steady rate to 67% of the minimum Failure Load and held for five minutes. This load shall then remove in a controlled manner and the Tension Assembly disassembled. Examination of the Tension Dead-End and associated components shall be made and any evidence of visual deformation shall be documented.

Part 2:

The Tension Dead-End and associated components shall then be reassembled and bolts tightened as before. The tensile load shall gradually be increased up shall gradually be increased up to 50% of the specified Minimum Failure Load of the Tension Assembly and held for one minute for the Test Rig to stabilise and the load shall be further increased at a steady rate until the specified minimum Failure Load is reached and held for one minute. No fracture should occur during this period. The applied load shall then be increased until the failing load is reached and the value shall be documented.

Acceptance Criteria for Tension/Suspension Assembly:

- No evidence of binding of the Nuts or Deformation of components at end of Part 1 of Test.

- No evidence of Fracture at the end of one minute at the minimum failure load during Part 2 of the Test.

Any result outside these parameters shall constitute a failure.

(ii) Clamp Slip Strength Test for Suspension Assembly

The suspension assembly shall be vertically suspended by means of a flexible attachment. A suitable length fibre optical cable shall be fixed in the clamps. Once the Suspension Clamp has been assembled, the test rig is tensioned to 1 kN and the position scale on the recorder ‘zeroed’. The test rig is then tensioned to 2.5 kN and the relative positions of the Reinforcing Rods, Armour Rods and Suspension Clamp shall be marked by a suitable means to confirm any slippage after the test has been completed. The relative positions of the helical Armour Rods and associated Reinforcing Rods at each end shall be marked and also 2 mm relative position between clamp body and Armour Rods shall be marked on one side. The load shall be increased to 12 kN at a loading rate of 3 kN/min and held for one minute. At the end of this one-minute period, the relative displacement between clamp body and the armour rods shall be observed. If the slippage is 2 mm or above, the test shall be terminated. Otherwise, at the end of one minute the position of the clamp body and 2 mm. relative positions between clamp body and armour rods shall be marked on the other side. After the one-minute pause, the load shall be further increased at a loading rate of 3 kN/min, and recording of load and displacement shall continue until either the relative Position displacement between clamp body and armour rods reaches more than 2 mm or the load reaches the maximum slip load of 17 kN. On reaching either of the above values the test is terminated. Visual examination of all paint marks shall be recorded, and a measurement of any displacement recorded in the Table of Results.

Acceptance Criteria:

The Suspension Clamp has passed the Slip Test if the following conditions are met:

- No slippage* shall occur at or below the specified minimum slip load.

*Definition of no slippage in accordance with IEC 61284, 1997:- Any relative movement less than 2 mm is accepted. The possible couplings or elongations produced by the cable as a result of the test itself are not regarded as slippage.

- Slippage shall occur between the specified maximum and minimum slip load of 12 -17 kN.
- There shall be no slippage of the Reinforcing Rods over the cable, and no slippage of the Armour Rods over the Reinforcing Rods.
- The relative movement (i.e. more than 2 mm between Armour Rods & Clamp body) between minimum 12 kN and maximum slip 17 kN, shall be considered as slip.
- The Armour Rods shall not be displaced from their original lay or damaged**.

** Definition of no damage in accordance with convention expressed in IEC 61284:

1997 no damage, other than surface flattening of the strands shall occur.

Any result outside these parameters is a failure.

(iii) Slip Strength Test of Tension Clamp

Tension clamps shall be fitted on an 8 m length of fibre optic cable on both ends. The assembly shall be mounted on a tensile testing machine and anchored in a manner similar to the arrangement to be used in service. A tensile load shall gradually be applied up to 20 % of the RTS of OPGW. Displacement transducers shall be installed to measure the relative movement between the OPGW relative to the Reinforcing Rods and Tension Dead –End relative to Reinforcing Rods. In addition, suitable marking shall be made on the OPGW and Dead-End to confirm grip. The load shall be gradually increased at a constant rate up to 50 % of the UTS and the position scale of the recorder is zeroed. The load shall then gradually increase up to 95 % of the UTS and maintained for one minute. After one-minute pause, the load shall be slowly released to zero and the marking examined and measured for any relative movement.

Acceptance Criteria:

- No movement* shall occur between the OPGW and the Reinforcing Rods, or between the Reinforcing Rods and the Dead-End assembly.

- No failure or damage or disturbance to the lay of the Tension Dead-End, Reinforcing Rods or OPGW.

* Definition of no movement as defined in IEC 61284: Any relative movement less than 2 mm is accepted. The possible couplings or elongations produced by the conductor as a result of the test itself are not regarded as slippage. Any result outside these parameters shall constitute a failure.

(iv) Grounding Clamp and Structure Mounting Clamp Fit Test

For structure mounting clamp, one series of tests shall be conducted with two fibre optic cables installed, one series of tests with one fibre optic cable installed in one groove, and one series of tests with one fibre optic cable in the other groove. Each clamp shall be installed including clamping compound as required on the fibre optic cable. The nut shall be tightened on to the bolt by using torque wrench with a torque of 5.5 kgm or supplier's recommended torque and the tightened clamp shall be held for 10 minutes. After the test remove the fibre optic cable and examine all its components for distortion, crushing or breaking. Also, the fibre optic cable shall be checked to ensure free movement within the core using dial callipers to measure the diameter of the core tube. The material shall be defined as failed if any visible distortion, crushing, cracking or breaking of the core tube is observed or the fibre optic cable within the core tube is not free to move, or when the diameter of the core tube as measured at any location in the clamped area is more than 0.5 mm larger or smaller of the core diameter as measured outside the clamped area.

(v) Structure Mounting Clamp Strength Test

The clamp and mounting assembly shall be assembled on a vertical 200 mm x 200 mm angle and a short length of fibre optic cable installed. A vertical load of 200 kg shall be applied at the end of the mounting clamp and held for 5 minutes. Subsequently, the load shall be increased to 400 kg and held for 30 seconds. Any visible distortion, slipping or breaking of any component of the mounting clamp or assembly shall constitute failure.

46.1.9.6 Type Test on Vibration Damper

(a) Dynamic Characteristic Test

The damper shall be mounted with its clamp tightened with torque recommended by the manufacturer on shaker table capable of simulating sinusoidal vibrations for Critical Aeolian Vibration frequency band ranging from 0.18/d to 1.4/d – where d is the OPGW cable diameter in meters. The damper assembly shall be vibrated vertically with a ±1 mm amplitude from 5 to 15 Hz frequency and beyond 15 Hz at 0.5 mm to determine following characteristics with the help of suitable recording instruments.

(i) Force Vs frequency

(ii) Phase angle Vs frequency

(iii) Power dissipation Vs frequency

The Force Vs frequency curve shall not show steep peaks at resonance frequencies and deep troughs between the resonance frequencies. The resonance frequencies shall be suitably spread within the Aeolian vibration frequency-band between the lower and upper dangerous frequency limits determined by the vibration analysis of fibre optic cable without dampers.

Acceptance criteria for vibration damper:

(i) The above dynamic characteristics test on five dampers shall be conducted.

(ii) The mean reactance and phase angle Vs frequency curves shall be drawn with the criteria of best fit method.

(iii) The above mean reactance response curve should lie within following limits: V.D. for OPGW - 0.060 f to 0.357 f kgf/mm* Where f is frequency in Hz.

(iv) The above mean phase angle response curve shall be between 25o to 130o within the frequency range of interest.

(v) If the above curve lies within the envelope, the damper design shall be considered to have successfully met the requirement.

(vi) Visual resonance frequencies of each mass of damper is to be recorded and to be compared with the guaranteed values.

(b) Vibration Analysis

The vibration analysis of the fibre optic cable shall be done with and without damper installed on the span. The vibration analysis shall be done on a digital computer using energy balance approach. The following parameters shall be taken into account for the purpose of analysis.

(i) The analysis shall be done for single fibre optic cable without armour rods. The tension shall be taken as 25% of RTS of fibre optic cable for a span ranging from 100 m to 1100 m.

(ii) The self damping factor and flexural stiffness (EI) for fibre optic cable shall be calculated on the basis of experimental results. The details to experimental analysis with these data shall be furnished.

(iii) The power dissipation curve obtained from Damper Characteristics Test shall be used for analysis with damper.

(iv) Examine the Aeolian Vibration level of the fibre optic cable with and without vibration damper installed at the recommended location or wind velocity ranging from 0 to 30 Km per hour, predicting amplitude, frequency and vibration energy input.

(v) From vibration analysis of fibre optic cable without damper, antinode vibration amplitude and dynamic strain levels at clamped span extremities as well as antinodes shall be examined and thus lower and upper dangerous frequency limits between which the Aeolian vibration levels exceed the specified limits shall be determined.

(vi) From vibration analysis of fibre optic cable with damper(s) installed at the recommended location, the dynamic strain level at the clamped span extremities, damper attachment point and the antinodes on the fibre optic cable shall be determined. In addition to above damper clamp vibration amplitude and antinodes vibration amplitudes shall also be examined.

The dynamic strain levels at damper attachment point, clamped span extremities and antinodes shall not exceed the specified limits. The damper clamp vibration amplitude shall not be more than that of the specified fatigue limits.

(c) Fatigue Tests

(i) Test Set Up

The fatigue tests shall be conducted on a laboratory set up with a minimum effective span length of 30m. The fibre optic cable shall be tensioned at 25% of RTS of fibre optic cable and shall not be equipped with protective armour rods at any point. Constant tension shall be maintained within the span by means of lever arm arrangement.

After the fibre optic cable has been tensioned, clamps shall be installed to support the fibre optic cable at both ends and thus influence of connecting hardware fittings are eliminated from the free span. The clamps shall not be used for holding the tension on the fibre optic cable. There shall be no loose parts, such as suspension clamps, U bolts, on the test span supported between clamps mentioned above. The span shall be equipped with vibration inducing equipment suitable for producing steady standing vibration. The inducing equipment shall have facilities for step less speed control as well as step less amplitude arrangement. Equipment shall be available for measuring the frequency, cumulative number of cycles and amplitude of vibration at any point along the span.

(ii) Fatigue Test

The vibration damper shall be installed on the test span with the manufacturer's specified tightening torque. It shall be ensured that the damper shall be kept minimum three loops away from the shaker to eliminate stray signals influencing damper movement.

The damper shall then be vibrated at the highest resonant frequency of each damper mass. For dampers involving torsional resonant frequencies, tests shall be done at torsional modes also in addition to the highest resonant frequencies at vertical modes. The resonance frequency shall be identified as the frequency at which each damper mass vibrates with the maximum amplitude on itself. The amplitude of vibration of the damper clamp shall be maintained not less than ±25/f mm where f is the frequency in Hz.

The test shall be conducted for minimum ten million cycles at each resonant frequency mentioned above. During the test, if resonance shift is observed, the test frequency shall be tuned to the new resonant frequency.

The clamp slip test as mentioned herein shall be repeated after fatigue tests without retorquing or adjusting the damper clamp, and the clamp shall withstand a minimum load equal to 80% of the slip strength for a minimum duration of one minute.

After the above tests, the damper shall be removed from fibre optic cable and subjected to dynamic characteristics test. There shall not be any major deterioration in the characteristics of the damper. The damper then shall be cut open and inspected. There shall not be any broken, loose, or damaged part. There shall not be significant deterioration or wear of the damper. The fibre optic cable under clamp shall also be free from any damage.

For purposes of acceptance, the following criteria shall be applied:

(1) There shall not be any resonant frequency shift before and after the test by more than ± 20%

(2) The power dissipation of the damper before and after test at the individual resonant frequencies do not differ by more than ± 20% Beside above tests, the type tests listed below in the table shall also be conducted on Vibration Damper.

Sl No	Test Name	Test Procedure
1	Visual examination & Dimensional and material verification	IEC 61897 Clause 7.1 & 7.2
2	Clamp Slip test	IEC 61897 Clause 7.5
3	Clamp bolt tightening test	IEC 61897 Clause 7.7
4	Attachments of weights to messenger cable	IEC 61897 Clause 7.8
5	Attachment of clamps to messenger cable	IEC 61897 Clause 7.8
6	Damper effectiveness evaluation	IEC 61897 Clause 7.11.3.2

46.1.9.7 Type Tests for Splice Enclosures (Joint Box)

Following Type tests shall be demonstrated on the Splice Enclosure(s) (Splice Enclosure/Box). For certain tests, lengths of the fibre optic cable shall be installed in the splice box, and the fibres must be spliced and looped in order to simulate conditions of use. The attenuation of the fibres shall be measured, during certain tests, by relevant Fibre Optic Test Procedures (EIA/TIA 455 or IEC 60794-1 procedures).

(i) Temperature Cycling Test

FO cable is installed in the splice enclosure and optical fibres spliced and looped. The box must be subjected to 5 cycles of temperature variations of -40°C to +65°C with a dwell time of at least 2 hours on each extreme. Fibre loop attenuation shall be measured in accordance with EIA 455-20 / IEC 60794-1-C10. The variation in attenuation shall be less than ±0.05dB. The final humidity level, inside the box, shall not exceed the initial level, at the closing of the box.

(ii) Humid Heat test

The sealed splice enclosure, with fibres spliced and looped inside, must be subjected to a temperature of +55°C ±2°C with a relative humidity rate of between 90% and 95% for 5 days. The attenuation variation of the fibres during the duration of the test shall be less than ±0.05dB, and the internal humidity rate measured, less than 2%.

(iii) Rain Withstand Test / Water Immersion test

The splice enclosure with optical fibres cable installed and fibres spliced fixed, shall be subjected to 24 hours of simulated rain in accordance with IEC 60060 testing requirements. No water seepage or moisture shall be detected in the splice enclosure. The attenuation variation of the fibres after the test shall be less than ±0.05dB.

(iv) Vibration Test

The splice enclosure, with fibres united inside, shall be subjected to vibrations on two axes with a frequency scanning of 5 to 50 Hz. The amplitude of the vibrations shall be constant at 0.450mm, peak to peak, for 2 hours, for each of the vibrations' axes. The variation in attenuation, of the fibres, shall be less than ±0.05dB. The splice enclosure shall be examined for any defects or deformation. There shall be no loosening or visible damage of the FO cable at the entry point.

(v) Bending and Torsion test

The splice enclosure, with fibres spliced inside, shall be firmly held in place and be subjected to the following sequence of mechanical stresses on the cable:

a) 3 torsion cycles of ±180° shall be exercised on the cable. Each cycle shall be less than one minute.

b) 3 flexure cycles of the cable, of ±180° with one cycle less than one minute.

The variation in the attenuation, of the fibres, shall be less than ±0.05dB. The cables connection ring shall remain securely fixed to the box with the connection maintained firmly. No defects/fissures shall be noted on the joint ring or on the splice enclosure

(vi) Tensile test

The splice enclosure with cable fixed to the boxes shall be subjected to a minimum tension of 448 N for a period of two minutes. No fissure shall be noted in the connections or on the box.

(vii) Drop Test

With 2 lengths of 11 metres of cable fixed to the box, it shall be dropped five times from a height of 10 metres. There shall be no fissure, at all, of the box, and the connections shall remain tight. The test surface shall be carried out in accordance with IEC 60068-2-32.

46.1.9.8 Type Tests for Fibre Optic Approach Cable

The type tests to be conducted on the Fibre Optic Approach cable are listed in Table 2-3: Type Tests for Fibre Optic Approach Cable. Unless specified otherwise in the technical specifications or the referenced standards, the optical attenuation of the specimen, measured during or after the test as applicable, shall not increase by more than 0.05 dB/Km.

Sl No	Test Name	Test Procedure
1	Water Ingress Test	(IEC 60794-1-F5 / EIA 455-82B) Test duration : 24 hours
2	Seepage of filling	(EIA 455-81A)
	compound	Preconditioning : 72 hours, Test duration : 24 hours.
3	Crush Test	(IEC 60794-1-E3/ EIA 455-41)
4	Impact Test	(IEC-60794-1-E4/ EIA 455-25A)
5	Stress strain Test	(EIA 455-33A)
6	Cable Cut-off wavelength Test	(EIA 455-170)
7	Temperature Cycling Test	(IEC60794-1-F1/EIA-455-3A) – 2 cycles

46.1.9.10 Impact Test

The Impact test shall be carried out in accordance with IEC:60794-1-E4. Five separate impacts of 2.0 kg shall be applied at different locations. The radius of the intermediate piece shall be the reel drum radius ± 10%. A permanent or temporary increase in optical attenuation value greater than 0.05 dB/km shall constitute failure.

46.1.9.11 Factory Acceptance Tests

Factory acceptance tests shall be conducted on randomly selected final assemblies of all equipment to be supplied. Factory acceptance testing shall be carried out on OPGW Cable and associated hardware & fittings, Approach Cable, Joint Box, FODP etc. and all other items for which price has been identified separately in the Bid Price Schedules.

Material shall not be shipped to the Employer until required factory tests are completed satisfactorily, all variances are resolved, full test documentation has been delivered to the Employer, and the Employer has issued Material Inspection & Clearance Certificate (MICC). Successful completion of the factory tests and the Employer approval to ship, shall in no way constitute final acceptance of the system or any portion thereof. These tests shall be carried out in the presence of the Employer's authorised representatives unless waiver for witnessing by Employer’s representatives is intimated to the contractor.

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

The factory acceptance tests for the supplied items shall be proposed by the Contractor in accordance with technical specifications and Contractor's (including Sub-Contractor's / supplier's) standard FAT testing program. In general, the FAT for other items shall include at least: Physical verification, demonstration of technical characteristics, various operational modes, functional interfaces etc. For Test equipment FAT shall include supply of proper calibration certificates, demonstration of satisfactory performance, evidence of correct equipment configuration and manufacturer's final inspection certificate/ report.

46.1.9.12 Sampling for FAT

From each batch of equipment presented by the Contractor for Factory acceptance testing, the Employer shall select random sample(s) to be tested for acceptance. Unless otherwise agreed, all required FAT tests in the approved FAT procedures, shall be performed on all samples. The Sampling rate for the Factory acceptance tests shall be minimum 10% of the batch size (minimum 1) for all items. The physical verification shall be carried out on 100% of the offered quantities as per the approved FAT procedure. In case any of the selected samples fail, the failed sample is rejected and additional 20% samples shall be selected randomly and tested. In case any sample from the additional 20% also fails the entire batch may be rejected.

For the OPGW cable hardware fittings & accessories, the minimum sampling rate, and batch acceptance criteria shall be as defined in IS 2486.

The Sampling rate for the Factory acceptance tests shall be 10% of the batch size (minimum 2) for FO cable drums, FODPs, Joint box and other similar items. Since FAT testing provides a measure of assurance that the Quality Control objectives are being met during all phases of production, the Employer reserves the right to require the Contractor to investigate and report on the cause of FAT failures and to suspend further testing/ approvals until such a report is made and remedial actions taken, as applicable.

46.1.9.13 Production Testing

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

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

46.1.9.14 Factory Acceptance Tests on Optical Fibre to be supplied with OPGW

The factory acceptance tests listed in table below are applicable for the Optical fibres to be supplied. The listed tests follow testing requirements set forth in IEEE standard 1138/IEC 60794. The referenced sections specify the detailed test description. The acceptance norm shall be as specified in the above-mentioned IEEE standards unless specified otherwise in the technical specifications.

Table 2-4
Factory Acceptance Tests for Optical Fibres: Optical Tests

Sl No	Test Name	Acceptance Criteria	Test Procedure
1	Attenuation Coefficient	T S,Table 1-1(a)	EIA/TIA 455- 78A
2	Point Discontinuities of attenuation	TS, Section 1.1.2	EIA/TIA 455-59
3	Point Discontinuities of attenuation	TS ,Table 2-1(a)	EIA/TIA 455- 78A
4	Chromatic Dispersion		EIA/TIA 455-168A/169A/175A
5	Core – Clad Concentricity Error		EIA/TIA 455-/176
6	Cladding diameter		EIA/TIA 455-176
7	Fibre Tensile Proof Testing		EIA/TIA 455-31B

The test report for the above tests for the fibers carried out by the Fiber Manufacturer and used in the OPGW cables shall be shown to the inspector during OPGW cable FAT and shall be submitted along with the OPGW cable FAT report.

46.1.9.15 Factory Acceptance Test on OPGW Cable

The factory acceptance tests for OPGW cable specified below in Table follow the requirements set forth in IEEE standard 1138 / IEC 60794. The FAT shall be carried out on 10% of offered drums in each lot as specified in technical specifications and the optical tests shall be carried out in all fibres of the selected sample drums. The Rated Tensile Strength test shall be carried out on one sample in each lot.

Table 2-5
Factory Acceptance Tests on OPGW
Applicable standard: IEEE 1138 / IEC 60794

Sl No	Factory Acceptance Test on Manufactured OPGW
1	Attenuation Co-efficient at 1310 nm and 1550 nm
2	Point discontinuities of attenuation
3	Visual Material verification and dimensional checks as per approved DRS/Drawings
4	Rated Tensile Strength
5	Lay Length Measurements

46.1.9.16 Factory Acceptance Test on OPGW Fittings

The factory acceptance tests for OPGW Fittings as specified below in Table 2-6. The sampling plan shall be as per relevant standard:

Table 2-6
Factory Acceptance Tests On OPGW Fittings

S. No.	Factory Acceptance Test
Suspension Assembly	
1	UTS/Mechanical Strength of the assembly
2	Clamp Slip Test
3	Visual Material verification and dimensional checks as per approved DRS/Drawings
4	Mechanical strength of each component
5	Galvanising test
Tension Assembly	
6	Clamp Slip Strength test
7	Visual Material verification and dimensional checks as per approved DRS/Drawings
8	Mechanical strength of each component
9	Galvanising Test
Vibration Damper	
10	Galvanising test on damper, masses and messenger wires
11	Damper response (resonant frequencies)
12	Clamp Slip test
13	Strength of messenger wires
14	Attachments of weights to messenger cable
Factory Acceptance Test	
15	Attachments of clamps to messenger cable
16	Clamp bolt tightening test
17	Clamp bolt torque test
18	Dynamic characteristic test.
19	Visual Material verification and dimensional checks as per approved DRS/Drawings
Structure Mounting Clamp	
20	Clamp fit test
21	Clamp Strength test
22	Visual Material verification and dimensional checks as per approved DRS/Drawings

46.1.9.17 Factory Acceptance Test on Approach Cable

The factory acceptance tests for Approach Cable specified below in Table 2-7:

Table 2-7
Factory Acceptance Tests On Approach Cable

Sl No	Factory Acceptance Test
1	Attenuation Co-efficient at 1310 nm and 1550 nm
2	Point discontinuities of attenuation
3	Visual Material verification and dimensional checks as per approved DRS/Drawings

46.1.9.18 Factory Acceptance Test on Splice Enclosure (Joint Box) /FODP

The factory acceptance tests for Splice Enclosures/FODP as specified below in Table: 2 8

Table 2-8
Factory Acceptance Tests on Splice Enclosures (Joint Box)/FODP

S. No.	Factory Acceptance Test
1	Visual check of Quantities and Specific Component Number for each component of Splice Enclosure/FODP and dimensional checks against the approved drawings.

46.1.9.19 Factory Acceptance Test on Test Equipment & other items

As per technical specification and approved DRS/Documents.

46.1.9.20 Site Acceptance Tests

The Contractor shall be responsible for the submission of all material & test equipment supplied in this contract for site tests and inspection as required by the Employer. All equipment shall be tested on site under the conditions in which it will normally operate.

The tests shall be exhaustive and shall demonstrate that the overall performance of the contract works satisfies every requirement specified. At a minimum Site Acceptance Testing requirement for FO cable etc. is outlined in following section. This testing shall be supplemented by the Contractor's standard installation testing program, which shall be in accordance with his quality plan(s) for FO installation.

During the course of installation, the Employer shall have full access for inspection and verification of the progress of the work and for checking workmanship and accuracy, as may be required. On completion of the work prior to commissioning, all equipment shall be tested to the satisfaction of the Employer to demonstrate that it is entirely suitable for commercial operation.

46.1.9.21 Minimum Site Acceptance Testing Requirement for FO Cabling

Prior to installation, every spooled fibre optic cable segment shall be tested for compliance with the Pre-shipment data previously received from the manufacturer. This requirement will preclude the installation of out of specification cable segments that may have been damaged during shipment.

46.1.9.22 Phases of Site Acceptance Testing

SAT shall be carried out link by link from FODP to FODP. SAT may be performed in parts in case of long links. The tests, checks, adjustments etc conducted by the Contractor prior to offering the equipment for SAT shall be called Pre-SAT activities. The Pre-SAT activities shall be described in the installation manuals and Field Quality Plan documents. Sag and tension of OPGW shall generally be as per approved sag-tension chart and during installation, sag and tension of OPGW shall be documented. Upon completion of a continuous cable path, all fibres within the cable path shall be demonstrated for acceptance of the cable path. Fibre Optic cable site testing minimum requirements are provided in Table 2- 9(a) through 2-9(c) below:

Table 2-9(a)
Fibre Optic Cable Pre-Installation Testing

Item:	Description:
1	Physical Inspection of the cable assembly for damage
2	Optical fibre continuity and fibre attenuation with OTDR at 1550 nm
3	Fibre Optic Cable length measurement using OTDR

Table 2-9(b)
Fibre Optic Cable Splicing Testing

Item:	Description:
1	Per splice bi-directional average attenuation with OTDR
2	Physical inspection of splice box/enclosure for proper fibre / cable routing techniques
3	Physical inspection of sealing techniques, weatherproofing, etc.

Table 2-9(c)
Fibre Optic Cable Commissioning Testing

Item:	Description:
1	End to End (FODP to FODP) bi-directional average attenuation of each fibre at 1310 nm and 1550 nm by OTDR.
2	End to End (FODP to FODP) bi-directional average attenuation of each fibre at 1310 nm and 1550 nm by Power meter.
3	Bi-directional average splice loss by OTDR of each splice as well as for all splices in the link (including at FODP also).
4	Proper termination and labelling of fibres & fibre optic cables at FODP as per approved labelling plan.

46.1.10 Installation of OPGW Cabling

46.1.10.1 OPGW cable installation requirements

The following shall be under the scope of OPGW Cabling:

- Supply of OPGW Cable & Hardware Fittings needed to tie the OPGW cable to the towers/gantries.
- Supervision of stringing of OPGW Cable at sites as per instruction by Employer. The supervision shall include the inspection as per stringing procedure, proper location of drum site, installation of stringing blocks/pulleys, proper sagging, proper installation of hardware, proper tension as per Sag-Tension chart, provision of service loops of OPGW in jointing locations
- The Splicing work of OPGW Cable and after that testing of link.

46.1.10.3 Installation Hardware

All required hardware’s shall be installed along with OPGW Cable.

46.1.10.4 Installation of Approach Cable

The existing cable trenches/ cable raceways proposed to be used shall be identified in the survey report. The Contractor shall make its best effort to route the cable through the existing available cable trenches. Where suitable existing cable trenches are not available, suitable alternatives shall be provided after Employer approval. However, the approach cable shall be laid in the HDPE pipe in all condition. Suitable provisions shall be made by the Contractor to ensure adequate safety earthing and insulated protection for the approach cable. All required fittings, supports, accessories, ducts, inner ducts, conduits, risers and any item not specially mentioned but required for laying and installation of approach cables shall be supplied and installed by the Contractor.

46.1.10.5 Optical Fibre Termination and Splicing

Optical fibre terminations shall be installed in Fibre Optic Distribution Panels (FODP) designed to provide protection for fibre splicing of preconnectorized pigtails and to accommodate connectorized termination and coupling of the fibre cables. The Contractor shall provide rack /wall mounted Fibre Optic Distribution Panels (FODPs) sized as indicated in the appendices and shall terminate the fibre optic cabling up to the FODPs. The location of FODP rack shall be fixed by the Contractor, with the Employer's approval.

46.1.10.6 Fibre Optic Distribution Panel

At each location requiring the termination of at least one fibre within a cable, all fibres within that cable shall be connectorized and terminated in Fibre Optic Distribution Panels in a manner consistent with the following:

(a) All fibre optic terminations shall be housed using FODPs provisioned with splice organizers and splice trays. All fibres within a cable shall be fusion spliced to pre-connectorized pigtails and fitted to the "Back-side" of the provided fibre optic couplings.

(b) Flexible protection shall be provided to the patch cord bunches going out from FODP to other equipment.

46.1.10.7 Methodology for Installation and Termination

All optical fibre cable termination, installation, stringing and handling plans, guides and procedures, and engineering analysis (e.g. tension, sag, vibration etc.) shall be submitted to the Employer for review and approval in the engineering/design phase of the project, prior to establishing the final cable lengths for manufacture. Installation procedures including details of personnel and time required shall be documented in detail and submitted to Employer for approval. All installation practices shall be field proven and ISO accredited.

All cable segments shall include service loops as specified in this specification .The maximum allowable stringing tension, maximum allowable torsional shear stress, crush strength and other physical parameters of the cable shall not be exceeded. The preventative measures to be taken shall be documented in detail and submitted to Employer in advance of installation.

Optical fibre attenuation shall be measured after installation and before splicing. Any increase in attenuation or step discontinuity in attenuation shall not be acceptable and shall constitute a cable segment failure. In the event of cable damage or any fibre damage, the complete section (tension location to tension location) shall be replaced as mid-span joints are not acceptable.

Any or all additional steel work or modifications required to attach the fibre cabling to the overhead transmission/ distribution line towers shall also be carried out by the Contractor. It shall be the Contractors responsibility to provide adequate communications among all crew members and support staff to ensure safe and successful installations.

46.1.16.0 Cable Raceways

To the extent possible, existing cable raceways shall be utilised. The Contractor is required to provide and install any additional indoor cable raceways which may be required for proper implementation of the fibre optic cabling system. This requirement shall be finalised during survey. The cable raceways shall conform to the following:

(a) All cable raceways shall be sized to support full loading requirements plus at least a 200% safety loading factor.

(b) Indoor cable raceways shall be fabricated from construction grade aluminium, galvanized iron or anodized sheet metal or any other suitable material approved by the Employer. Suitable anticorrosion measures shall be provided. Steel fabricated raceways shall be finished inside and out, treated to resist rust and to form a metal-to- paint bond.

(c)Mechanical construction drawings of the cable raceways shall be submitted for Employer's information & review

APPENDIX-A
Table A-1
Typical transmission line details (To be filled by the Bidder)

Line Voltage	S/C or D/C	Nominal Span (E/W & Conductors in mtrs.)	Wind Zone as per IS 802	Design Tension at Every Day Temp (32º C) and full wind condition – Earthwire) in kg	Wind Pressure (kg/Sq-m) considering gust factor	Max Sag – Ground Wire at 53ºC (in mtrs)	UTS – Earthwire (in Kg)	Weight – Earth wire (in Kg/km)	Minimum Clearance in mtrs.		
									A1	B1	C1
400KV	S/C										
	D/C										
220 KV	S/C										
	D/C										
132 KV	S/C										
	D/C										

A1 Minimum clearance between conductor and ground (in meters)

B1 Minimum clearance between two phase conductors (in meters) – vertical in case of D/C towers and horizontal in case of S/C towers.

C1 Minimum clearance between conductor and earth wire (in meters)