

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, earthing 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 Arresters 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 disconnecter 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 Disconnect 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.

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.

Continuous bus lengths without gas segregation shall not be acceptable for any voltage level.

Each section shall be provided with necessary valves to allow evacuation and refill of gas without evacuation of any other section.

The gas system proposed shall be submitted with the proposal. External fixtures shall be of non-corrosive material and be capped wherever required.

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.

Support insulators shall be used to maintain the conductors and enclosure in proper relation.

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.

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 $\leq$ 150 PPM (volume) Others $\leq$ 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.

16.4.10 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 (if applicable)

16.4.11 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 disconnector of the bus bars, with one bus bar remaining in service.

- 16.4.12 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.
- 16.4.13 Each section shall have plug- in or easily removable connection pieces to allow for easy replacement of any component with the minimum of disturbance to the remainder of the
- 16.4.14 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.**
- 16.4.15 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.
- 16.4.16 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.
- 16.4.17 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.
- 16.4.18 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.
- 16.4.19 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.
- 16.4.20 The thermal rating of all current carrying parts shall be minimum for three sec. for the rated symmetrical short-circuit current.
- 16.4.21 The arrangement of the individual switchgear bays shall be such so as to achieve optimum space-saving, neat and logical arrangement and adequate accessibility to all external components.
- 16.4.22 The layout of the substation equipment, bus bars and switchgear bays shall preferably be based on the principle of "phase grouping". Switchgear layout based on the "mixed phases" principle shall not be accepted without mutual agreement between supplier and employer.

- 16.4.23 The arrangement of the equipment offered must provide adequate access for operation, testing, Repair and maintenance.
- 16.4.24 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.**
- 16.4.25 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.
- 16.4.26 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.
- 16.4.27 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.**
- 16.4.28 The enclosure shall be of continuous design and shall meet the requirement as specified in of IEEE 80 2013 (special considerations for GIS).
- 16.4.29 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.
- 16.4.30 The fabricated metal enclosure shall be of Aluminium alloy/high grade steel having high resistance to corrosion, low electrical losses and negligible magnetic losses.
- 16.4.31 . 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.
- 16.4.32 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.
- 16.4.33 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.
- 16.4.34 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.**

- 16.4.35 In addition to above suitable portable scissor lift shall be provided for access of distant portion of GIS installation.
- 16.4.36 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.
- 16.4.37 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.
- 16.4.38 The sealing provided between flanges of two modules / enclosures shall be such that long term tightness is achieved.
- 16.4.39 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.
- 16.4.40 The equipment will be operated under the following ambient conditions (or as defined in this section project):
- a) The ambient temperature varies between 0 degree-C and 50 degree-C. However, for design purposes, ambient temperature should be considered as 50 degree-C.
 - b) The humidity will be about 95% (indoors)
 - c) The elevation is less than 1000 meters
- 16.4.41 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.
- 16.4.42 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.

16.4.43 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 may be provided and shall be of following types:-

1. Lateral / Vertical mounting units: These shall be inserted, as required, between sections of busbars, on transformer, 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.

16.4.44 Indication and verification of switch positions: Indicators shall be provided on all circuit breakers, isolators and earth-switches, which shall clearly show whether the switches are open or closed. The indicators shall be mechanically coupled directly to the main contact operating drive rod or linkages and shall be mounted in a position where they are clearly visible from the floor or the platform in the vicinity of the equipment.

Inspection windows shall also be provided with all isolators and earth switches so that the switch contact positions can be verified by direct visual inspection.

16.4.45 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 directly into the atmosphere in a controlled direction.

If the pressure relief devices vent directly into the atmosphere, suitable guards and deflectors shall be provided.

- 16.4.46 **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.

16.4.47 **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 the GIS 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.

16.4.48 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.

16.4.49 **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.

16.4.50 **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.

16.4.51 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 so as to ensure that they are not affected by possible irritants of the skin and respiratory system. Recommendations shall be submitted for suitable protective clothing, method of disposal of cleaning utensils and other relevant matters.

The contractor shall also indicate the details and type of filters used in various gas sections, and should also submit the operating experience with such filters.

SF6 gas monitoring devices and alarm circuits: Dial type temperature compensated gas density monitoring devices with associated pressure gauge will be provided. The devices shall provide continuous & automatic (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.

16.4.52 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 shall be 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 module to XLPE cable termination end
- xx. The general arrangement drawing of Terminal connection arrangement to connect GIS 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 measurement and 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 overlap of 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 along with 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 puffered 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.

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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 resistor: 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

- 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 $U/\sqrt{3}$ and 1.4
- Clearing terminal fault (100%) & short line fault (Kilometric faults) with source impedance behind the bus equivalent to symmetrical fault current specified.
- Breaking 25% the rated fault current at twice the rated voltage under phase opposition condition.
- 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.
- 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 :

- Test duties T10,T30,T60,T100 (with TRV as per IEC- 62271-100)
- 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.

factor may.

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 monitored for remote annunciations and operation lockout in case of dc failures.
- g) The auxiliary switch of the breaker shall be positively driven by the breaker operating rod.

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 also be performed.

- i. Speed curves for each breaker shall be obtained with the help of a suitable operation analyzer to determine the breaker contact movement during opening, closing, auto reclosing and trip free operation under normal as well as limiting operating **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 shall be 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 conform to all three test duties viz TD1, TD2 and TD3 as per Annexure –F of IEC: 62271- 102. They shall also be able to make and break rated bus transfer current at rated bus transfer voltage which appears during transfer between bus bars in accordance with Annexure –B of IEC: 62271-102. The contact shielding shall also be designed to prevent restrikes and high local stresses caused by transient recovery voltages when these

currents are interrupted.

- 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 in the 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 the remote/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 conform 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) and 6 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 V_k 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 be as 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 except to the extent explicitly modified in the specification.

Voltage transformers shall be of the electromagnetic type with SF6 gas insulation. The earth end of the high voltage winding and the ends of the secondary winding shall be brought out in the terminal box.

- 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.
Secondary 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 secondary terminal box.
- viii) It should be ensured that access to secondary terminals is without any danger of access to 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. The type 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 145kV and above voltage rating

16.5.1.15 SURGE ARRESTORS

16.5.1.18.1 The surge arrestors shall conform in general to latest IEC –60099-4.

16.5.1.18.2

Insulation co-ordination and selection of surge arrester: The contractor shall be fully responsible for complete insulation co-ordination of switchyard including GIS. Contractor shall carry out detailed studies and design calculations to evolve the required parameters locations, energy capability etc. of surge arrestors such that adequate protective margin is available between peak impulse, surge and power frequency discharge voltages and BIL of the protected requirement. The locations of surge arrestors shown in single line diagram is indicative only. If the contractor feels that at some more locations the surge arrestors are required to be provided the same should also be deemed included in the offer.

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 arrester and shall demonstrate that the selected arrester's protective and withstand levels, discharge and coordinating currents and arrester 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

Utility requirements of GIS Surge Arrester

16.5.1.18.7.7

The surge arrester shall be SF6 gas insulated metal oxide and gapless type. The metal housing of the arrester shall be connected to the metal enclosure of the GIS with flange, bolted and gasketed joint so that the arrester housing is grounded through GIS enclosure.

16.5.1.18.7.8

Surge arrester 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 arrester 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 ground	± 2100	± 1550	± 1425	± 1050	± 1050	± 650
CB/Isolator Across open contacts	± 1300 (-/+457)	± 1200 (-/+653)	± 1425 (-/+240)	± 900 (-/+345)	± 1200	± 750

16.5.1.18.6

Constructional Features

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

The arrester enclosure shall be vertically or horizontally mounted to suit the layout of the switchgear as suggested by the supplier and each arrester shall be fitted with a Online continuous resistive leakage current monitoring system. The system shall be provided with an interface to integrate with the substation automation system.

The main grounding connection from the surge arrester to the earth shall be provided by the contractor. The size of the connecting conductor shall be such that all the energy is dissipated to the ground without getting overheated.

16.5.1.18.7

ests

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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/AI 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 (see IEC 62271-209)
- 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 isolation gap 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 being in 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 Disconnect 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 bases shall 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 10MHz and 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 of 25% 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 all the 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 access 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 for 132kV Voltage 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 as SGS 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 Pendant Controller Pendant 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 of electromagnetic field on the surface of the enclosure.
- d) Calculations to show that there is no Ferro resonance due to capacitance of GIS for the voltage transformers.
- e) Calculations in support of touch & step voltages in all enclosures and earthing of complete 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's painting procedure.

16.9.2 **Heaters:** Wherever required, heaters shall be provided to prevent moisture condensation inside 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. Should the units be considered too large for packing in crates, they shall be suitably lagged and protected to prevent damage to any part, particularly small projections, during transport and handling. Special lugs or protective supports shall be provided for lifting to prevent slings and other lifting equipment from causing damage. Each crate, container or shipping unit shall be marked clearly on the outside to show where the weight is bearing and the correct position for the slings.
- 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 shipment to 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 to be 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 this room 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 violation of shock limits, expert from 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 before GIS 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 to be 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 dielectric 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 operational compatibility 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 compartment dismantled.

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
M³/Hour
Compressor (Two Stage): 15 M³/Hour
Oil Free Vacuum Pump: 100 M³/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 for the 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 for a 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, faulty communication 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 GIS for the design of sensors shall be furnished.
 15. The protection available for electronics against transient over voltages caused by switching 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 eliminating the 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 in the 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. The PC 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 shall also make available typical point-on-wave patterns 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/Msqared
- 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 H₂O, 33.5 ft of H₂O)
- 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 (U _{max}) 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°C	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 interrupting capability kA (rms)	63kA	50kA	40kA
8.	Rated short circuit making current kA	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 current carrying capability kA (rms)	15.75	As per IEC	As per IEC
11.	Rated line charging interrupting current at 90 deg. Leading power factor angle (A rms) (The breaker shall be able to interrupt the rated line charging current with test voltage immediately before opening equal to the product of U/√3 and 1.4 as per IEC-62271-100	600	As per IEC	As per IEC

CHAPTER 16: GIS EQUIPMENTS

12.	First pole to clear factor	1.3	1.3	1.3
13.	Temperature rise over an ambient temperature of 50°C	As per IEC: 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

CHAPTER 16: GIS EQUIPMENTS

21.	Max. difference in the instants of closing/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 voltage with 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 μ s) between line terminals and ground	□1425 kVp	□1050 kVp	□650 kVp
ii)	Full wave impulse withstand(1.2 /50 μ s) between terminals with circuit breaker open	1425 kVp impulse on 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 μ s) Dry & wet between line terminals and ground	+1050 kVp	NA	NA

CHAPTER 16: GIS EQUIPMENTS

iv)	Rated switching impulse withstand voltage (250/2500 μ s) 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 dry withstand voltage between line terminals and ground	520 kV rms.	460 kV rms.	275 kV rms
vi)	One minute power frequency dry withstand 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	320 kV rms	156 kV rms	92 kV rms
29.	Max. radio interference voltage for frequency between 0.5 MHz and 2 MHz (Micro volts)	1000 μ V (at 266 kV rms)	1000 μ V (at 156 kV rms)	500 μ V (at 92 kV 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°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 of isolator and earth switch(As applicable)	157.5 kAp	125 kAp.(As applicable)	100 kAp
8.	Rate insulation level:			
	One minute power freq. Withstand voltage: To earth :	650 kV rms.	460 kV rms.	275 kV rms.
	One minute powerfreq. Withstand	815 kV rms.	530 kV rms.	315 kV rms.

	voltage: Across isolating distance			
	1.2/50 micro sec. Lighting impulse withstand voltage (+ve or -ve polarity) To earth:	1425 kVp	± 1050 kVp	650kVp
	1.2/50 micro sec. Lighting impulse withstand voltage (+ve or -ve polarity) : Across Isolating distance	$\pm 1425/-+240$ kVp	$\square 1200$ kVp	As per IEC
	Rated switching impulse withstand voltage (250/2500 micro-sec.) Dry & wet :between line terminals and ground:	+/- 1050 kVp	N.A	N.A
	Rated switching impulse withstand voltage (250/2500 micro-sec.) Dry & wet :Between 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 clauses as 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 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
8	Number of poles		3		
9	Dynamic current	kA	157.5	125	100
12	Rated short-circuit withstand current (r.m.s.), 3s	kA	63	50	40
13	Type of operating mechanism		Motor operation		
14	Number of drives per 3 phase		1		
15	Control voltage (DC)	V	220 DC		
16	Number of CO operations permissible without maintenance	No.	As per latest IEC standard		

HIGH SPEED EARTH SWITCH					
SL.NO	SYSTEM PARAMETER S	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 per 3 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
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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($^{\circ}$ C)	50	50	50	50
6	System fault level (kA)	50kA for 1 sec	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 in a weather proof box			
ii)	For secondary winding	3kVrms			

11	Max. radio interference voltage for frequency between 0.5 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 System Operating 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 discharge current		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 insulation co-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 (referred to 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 wave residual voltage at 20 kA	kVp	1480	925	-	-
12	Long duration discharge class		5	4	3	3
13	High current short duration 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 Discharge at 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 impulse voltage (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