

TECHNICAL **SPECIFICATIONS**

CHAPTER 20- GAS INSULATED SUBSTATION (GIS)

for

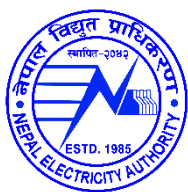
PACKAGE KC-6

of

KOSHI CORRIDOR 220kV TRANSMISSION LINE PROJECT

IFB No.: KOSHI/NEA/KC-6

**Procurement of Design, Supply, Installation, Testing
and Commissioning of 220kV(GIS)/132kV
Substation Expansion at Dhungesanghu Substation**



नेपाल विद्युत प्राधिकरण

(नेपाल सरकारको स्वामित्व)

Nepal Electricity Authority

(A Government of Nepal Undertaking)

Chapter 20: Gas Insulated Substation (GIS)

1. GENERAL

The GIS manufacturer shall design, manufacture, test, deliver and guarantee the GIS components and services as defined in this Technical Specification. The complete GIS based on the Single Line Diagram and as defined in Chapter1-PSR, 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 arrester (if applicable) etc.

2. GENERAL CHARACTERISTICS

- 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.
- 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
132/66 KV GIS	Three Phase enclosed

- 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.

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 GTR.

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 62271-203	Gas Insulated metal-enclosed switchgear for rated voltages above 52 KV
IEC 62271-207	Seismic qualification for gas-insulated switchgear assemblies for rated voltages above 52 kV
IEC 60376	New Sulphur Hexafluoride

IEC 62271- 100	High voltage alternating current Circuit breakers
IEC 62271-1	Common clauses for high voltage Switchgear and control-gear Standards
IEC 62271-102	Alternating current Disconnect Switch(isolate) and earthing switches
IEC 61869	General Requirements Instrument Transformers
IEC 60137	Bushings for alternating voltages above 1000 V
IEC 62271-209	Cable connections for gas-insulated switchgear
IEC 60480	Guide to checking of sulphur hexafluoride taken from electrical equipment
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. (Electra no.151, Dec'93).
IEC 62271-211	Direct connection between Power Transformers and gas insulated metal enclosed switchgear for rated voltage 72.5 kV and above.

The components and devices which are not covered by the above standards shall conform to, and comply with, the applicable standards, rules, codes and regulations of the internationally recognized standardizing bodies and professional societies as may be approved by the Employer and the manufacturer shall list all such applicable standards, codes etc.

In case the requirements laid down herein differ from those given in above standard in any aspect the switchgear shall comply with the requirements indicated herein in regard thereto.

4. DEFINITIONS

- 4.1. **Assembly:** Assembly refers to the entire completed GIS equipment furnished under contract.
- 4.2. **Bay:** Bay refers to the area occupied by one Circuit Breaker and associated equipment.
- 4.3. **Compartment:** When used in conjunction with GIS equipment, compartment refers to a gas tight volume bounded by enclosure walls and gas tight isolating barriers.
- 4.4. **Enclosure:** When used in conjunction with GIS equipment, enclosure refers to the grounded metal housing or shell which contains and protects internal Power system equipment (breaker, disconnecting switch, grounding switch, voltage transformer, current transformer, surge arresters, interconnecting bus etc.)
- 4.5. **Manual Operation:** Manual operation means operation by hand without using any other source of power.
- 4.6. **Module:** When used in conjunction with GIS equipment, module refers to a portion of that equipment. Each module includes its own enclosure. A module can contain more than one piece of equipment, for example, a module can contain a disconnecting switch and a grounding switch.

- 4.7. **Reservoir:** When used in conjunction with GIS equipment reservoir refers to a larger gas- tight volume.

5. GENERAL DESIGN AND SAFETY REQUIREMENT

- 5.1. The GIS shall be designed, manufactured and tested in accordance with the best international engineering practices under strict quality control to meet the requirement stipulated in the technical specification. Adequate safety margin with respect to thermal, mechanical, dielectric stress and insulation coordination etc. shall be maintained during design, selection of raw material, manufacturing process etc. so that the GIS provides long life with least maintenance.

The workmanship shall be of the highest quality and shall conform to the latest modern practices for the manufacture of high technology machinery and electrical switchgear.

- 5.2. 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.
- 5.3. 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.
- 5.4. 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.
- 5.5. 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.
- 5.6. 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)

Typical drawings indicating gas tight compartments are enclosed at **Annexure-A**. This is an indicative drawing only; however, GIS manufacturer shall ensure the service continuity requirement as mentioned above.

5.7. 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:

- 5.7.1. 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.
- 5.7.2. For Double Main bus switching scheme during a fault in CB compartment, No bus bar permitted out of service during maintenance and repair/replacement.
- 5.7.3. 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.
- 5.8. 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.
- 5.9. Each section shall have plug- in or easily removable connection pieces to allow for easy replacement of any component with the minimum of disturbance to the remainder of the equipment. Inspection windows (View Ports) shall be provided for Disconnect Switch and both type of earth switches i.e. Maintenance and fast operating.
- 5.10. 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.

- 5.11. 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.
- 5.12. 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 commissioning during warranty period, 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 warranty period. The maximum relative leakage rate for type tests should be less than or equal to 0.1% per year.
- 5.13. Each gas-filled compartment shall be equipped with static filters, density switches, filling valve and safety diaphragm. The filters shall be capable of absorbing any water 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.
- 5.14. 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.
- 5.15. The thermal rating of all current carrying parts shall be minimum for one sec. for the rated symmetrical short-circuit current.
- 5.16. 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.
- 5.17. 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. The arrangement of the equipment offered must provide adequate access for operation, testing, Repair and maintenance.
- 5.18. All the elements shall be accessible without removing support structures for routine inspections. The removal of individual enclosure parts or entire breaker bays shall be possible without disturbing the enclosures of neighboring bays and LCC panels.
- 5.19. 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.

- 5.20. 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. 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 400 kV and above.
- 5.21. The enclosure shall be of continuous design and shall meet the requirement as specified in of IEEE 80 2013 (special considerations for GIS).

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.
- 5.22. The fabricated metal enclosure shall be of Aluminium alloy having high resistance to corrosion, low electrical losses and negligible magnetic losses. All joint surfaces shall be machined and all castings shall be spot faced for all bolt heads or nuts and washers. All screws, bolts, studs and nuts shall 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.
- 5.23. The enclosure shall be designed to practically eliminate the external electromagnetic field and thereby electro-dynamic stresses even under short circuit conditions. The average intensity of electromagnetic field shall not be more than 50 micro Tesla on the surface of the enclosure.
- 5.24. 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.
- 5.25. For 400 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 either aluminum or 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.
- 5.26. In addition to above suitable portable Electric scissor lift shall be

provided for access of distant portion of GIS installation not covered by clause 5.25.

- 5.27. 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.
- 5.28. The enclosure & support structure shall be designed such that person of 1780 mm in height and 80 Kg in weight is able to climb on the equipment for maintenance.
- 5.29. The sealing provided between flanges of two modules / enclosures shall be such that long term tightness is achieved.
- 5.30. Alarm circuit shall not respond to faults for momentary conditions. The following indications including those required elsewhere in the specifications shall be generally provided in the alarm and indication circuits.

Gas Insulating System:

- i) Loss of Gas Density
- ii) Any other alarm necessary to indicate deterioration of the gas insulating system.

Operating System:

- i) Low operating pressure
 - ii) Loss of Heater power
 - iii) Loss of operating power
 - iv) Loss of control supply
 - v) Pole Discordance.
- 5.31. The equipment will be operated under the following ambient conditions (or as defined in the Chapter PSR):
 - 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
 - 5.32. 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.
 - 5.33. 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.
 - 5.34. **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.

- 5.35. **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.

- 5.36. **Pressure relief device:** Pressure relief devices shall be provided in the gas sections to protect the gas enclosures from damage or distortion during the occurrence of abnormal pressure increase or shock waves generated by internal electrical fault arcs (preferably in downward direction).

Pressure relief shall be achieved either by means of diaphragms or plugs venting directly into the atmosphere in a controlled direction.

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

- 5.37. **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.

- 5.38. **Grounding:**

- 5.39.1. 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.

- 5.39.2. 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.

- 5.39.3. The enclosure of the GIS may be grounded at several points so that there shall be grounded cage around all the live parts. A minimum of two nos. of grounding connections should be provided for each of circuit breaker, cable terminals, surge arrestors, earth switches and at each end of the bus bars. The grounding continuity between each enclosure shall be effectively interconnected either internally or externally with Copper/Aluminum bonds of suitable size to bridge the flanges. Subassembly to subassembly bonding shall be provided to bridge the gap & safe voltage gradients between all intentionally grounded parts of the GIS assembly & between those parts and the main grounding bus of the GIS.
- 5.39.4. Each marshaling box, local control panel, power and control cable sheaths and other non- current carrying metallic structures shall be connected to the grounding system of GIS via connections that are separated from GIS enclosures.
- 5.39.5. 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.
- 5.39.6. 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.
- 5.39.7. 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.

5.39. **UHF sensors for PD detection:**

Adequate number of UHF sensors shall be provided in the offered GIS of voltage level 220 kV or above for detection of Partial discharge (of 5 pC and above) 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*). 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.

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.

5.40. **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 & 66 kV).
- (2) GIB shall be generally in horizontal layer. However, in exceptional circumstance GIB in vertical layers can be provided with the approval of employer.
- (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) The price of Bus-duct inside the GIS hall shall be integral part of the respective bay module and it will not be paid separately. However, the payment of bus-duct for outside the GIS hall along with support structure shall be paid as per running meters in line with provision of Bid Price schedule.

5.41. **Extension of GIS**

5.42.1. 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.

5.42.2. 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 mentioned above necessary for design and successful implementation of an interface module during later stage while extending GIS by any other GIS manufacturer, without any help of GIS manufacturer who has supplied the GIS equipment in present scope.

5.42.3. 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.

5.42.4. 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.

5.42. **SF6 GAS**

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:

EN 1089/ IS: 4379 Identification of the contents of industrial gas cylinders.

ISO 9809/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. 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.

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.

- 5.43.1. **SF₆ gas monitoring devices and alarm circuits:** Dial type temperature compensated gas density monitoring devices with associated pressure gauge will be provided. The devices shall provide continuous & automatic monitoring of gas density. The gas density monitoring devices shall have IP rating of IP65 or better and Suitable canopy shall be provided to prevent ingress of rain water for outdoor application. 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	'Gas Refill' level : This will be used to annunciate the need for gas refilling. The contractor shall provide a contact
	contact for remote indication.	for remote indication.
2	"SF₆ low level" : This will be used to annunciate the need for urgent gas filling . A contact shall be provided for remote indication	"SF₆ low level" : This will be used to annunciate the need for urgent gas filling . A contact shall be provided for remote indication
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
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.

5.43.2. **Gas Supply:** The contractor shall include the supply of all SF₆ gas necessary for filling & putting into operation the complete switchgear installation being supplied. The empty gas cylinders shall be returnable to the contractor.

5.43. **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 as per clause no. **19** of this specification
- 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 details
- vii. Details for each type of rubber gasket, O-ring, sealing adhesive, and grease used in SF₆ gas-insulated switchgear (GIS) enclosures for the Employer's future reference.
- viii. Interface modules drawing for GIS extension
- ix. Rating and Name Plate Drawing
- x. GIS/LCC Schematics Drawing
- xi. Foundation loading plan and detail
- xii. GIS Support Structure Drawing
- xiii. GIS platforms and Walkway Drawing
- xiv. GIS grounding plan and details along with design calculation for GIS grounding
- xv. 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.
- xvi. Method Statement along with sequential instruction for dismantling and assembling of all major components of GIS exhibiting service continuity requirement
- xvii. Type Test Reports
- xviii. Seismic Analysis Report
- xix. Study report of VFTO generated for GIS installation for 400 kV and above.
- xx. The general arrangement drawing of interconnecting bus-duct from GIS bay module to XLPE cable termination end
- xxi. The general arrangement drawing of Terminal connection arrangement to connect GIS duct to SF₆/Oil bushing and duct mounting arrangement details
- xxii. Gas handling procedure
- xxiii. The design & construction proposal of the building along with necessary information, data, and drawings according to the

- complete requirements
- xxiv. Capacity calculation of EOT crane for GIS hall considering a factor of safety of 5
- xxv. Method statement/ procedure of ON-SITE high voltage testing with PD measurement and Switching Impulse test
- xxvi. Method statement/ procedure of replacement of major component (CB, CT, PT, DS, ES, FES, Bushing, LA, Operating mechanism of CB/DSES/FES) of GIS in futures.
- xxvii. **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
- xxviii. PD Monitoring System
 - a) The technical proposal for PDM system along with detailed design documentation.
 - b) Data sheet for the UHF couplers.
 - c) 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.
 - d) Guaranteed Technical Particulars & Data Sheet for various components used in the PDM system.
 - e) Electromagnetic compatibility Test Reports.
 - f) List of critical spares.
- xxix. Installation and Operation & Maintenance Manual

6. CIRCUIT BREAKERS

- 6.1. **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 and shall also be in accordance with requirements specified in Chapter-GTR.

Circuit breakers shall be equipped with the operating mechanism. Circuit breakers shall be of single pressure type. Complete circuit breaker with all necessary items for successful operation shall be supplied. The circuit breakers shall be designed for high speed single and three phase reclosing (as applicable) with an operating sequence and timing as specified.

- 6.2. **Duty Requirements:** Circuit breaker shall be C2 - M2 class as per IEC 62271-100.

Circuit breaker shall meet the duty requirements for any type of fault or fault location also for line charging and dropping when used on effectively grounded system and perform make and break operations as per the stipulated duty cycles satisfactorily.

6.3. **Pre insertion resister:** 400 kV circuit breakers for line bay (as per the provisions of BPS and PSR) 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 :

- a. **Terminal fault : Close.... 1 Min..... Open..... Close Open 2 min..... Close**
1 Min Open Close Open.
- b. **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.
- c. **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.

6.4. The circuit breaker shall be capable of:

1. Interrupting the steady and transient magnetizing current shall be as follows:

Voltage Level	Type of Transformer	Rating (in MVA)
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 315
	132/33kV	10 to100

2. Interrupting line/cable charging current as per IEC without re-strikes and without use of opening resistors. The breaker shall be able to interrupt the rated line charging current as per IEC-62271-100 with test voltage immediately before opening equal to the product of $U/\sqrt{3}$ and 1.4
3. Clearing short line fault (Kilometric faults) with source impedance behind the bus equivalent to symmetrical fault current specified.
4. Breaking 25% the rated fault current at twice the rated voltage under phase opposition condition.
5. The breaker shall satisfactorily withstand the high stresses imposed

on them during fault clearing, load rejection and re-energisation of shunt reactor and/or series capacitor compensated lines with trapped charges.

6. Withstanding all dielectric stresses imposed on it in open condition at lock out pressure continuously (i.e. shall be designed for 2 p.u. across the breaker continuously, for validation of which a power frequency withstand test conducted for a duration of at least 15 minutes is acceptable).
7. 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

- 6.5. **Total Break Time :** The total break time shall not be exceeded under any of the following duties :

- a) Test duties T10,T30,T60,T100 (with TRV as per IEC- 62271-100)
- b) Short line fault L90, L75 (with TRV as per IEC-62271-100)

The Contractor may please note that total break time of the breaker shall not be exceeded under any duty conditions specified such as with the combined variation of the trip coil voltage (70-110%), pneumatic/hydraulic pressure and SF6 gas pressure etc. While furnishing the proof for the total break time of complete circuit breaker, the contractor may specifically bring out the effect of non-simultaneity between poles and show how it is covered in the total break time.

The values guaranteed shall be supported with the type test reports.

- 6.6. **Constructional features:**

The features and constructional details of breakers shall be in accordance with requirements stated hereunder:

- 6.6.1. 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.
- 6.6.2. **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.
- 6.6.3. 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.
- 6.6.4. 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.

- 6.6.5. 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)
- 6.6.6. 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.
- 6.6.7. 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.
- 6.6.8. Circuit Breaker shall be supplied with auxiliary switch having additional 8 NO (normally open) and 8 NC (normally closed) contacts for future use over and above those required for switchgear interlocking and other control and protection function. These spare NO and NC contacts shall be wired upto the local control cubicle.
- 6.6.9. 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

6.7. **Operating mechanism**

6.7.1. General Requirements:

- a) Circuit breaker shall be operated by spring charged mechanism or electro hydraulic mechanism or a combination of these. The mechanism shall be housed in a dust proof cabinet and shall have IP: 42 degree of protection.
- b) The operating mechanism **box** shall be strong, rigid, rebound free and shall be readily accessible for maintenance.
- c) The operating mechanism shall be suitable for high speed reclosing and other duties specified. During reclosing the breaker contacts shall close fully and then open. The mechanism shall be anti-pumping and trip free (as per IEC definition) under every method of closing.
- d) The mechanism shall be such that the failure of any auxiliary spring will not prevent tripping and will not cause unwanted trip or closing operation of the Circuit Breaker.
- e) A mechanical indicator shall be provided to show open and close position of the breaker. It shall be located in a position where it will be visible to a man standing on the ground level with the mechanism housing closed. An operation counter shall also be provided.
- f) Working parts of the mechanism shall be of corrosion resisting material, bearings which require grease shall be equipped with pressure type grease fittings. Bearing pin, bolts, nuts and other parts shall be adequately pinned or locked to prevent loosening or changing adjustment with repeated operation of the breaker.
- g) The contractor shall furnish detailed operation and maintenance manual of the mechanism along with the operation manual for the

circuit breaker.

6.7.2. **Control**

- a) The close and trip circuits shall be designed to permit use of momentary-contact switches and push buttons.
- b) Each breaker pole shall be provided with two (2) independent tripping circuits and trip coils which may be connected to a different set of protective relays.
- c) The breaker shall normally be operated by remote electrical control. Electrical tripping shall be performed by shunt trip coils. However, provisions shall be made for local electrical control. For this purpose a local/remote selector switch and close and trip control switch/push buttons shall be provided in the breaker control cabinet.
- d) The trip coil shall be suitable for trip circuit supervision during both open and close position of breaker.
- e) Closing coil and associated circuits shall operate correctly at all values of voltage between 85% and 110% of the rated voltage. Shunt trip and associated circuits shall operate correctly under all operating conditions of the circuit breaker upto the rated breaking capacity of the circuit breaker and at all values of supply voltage between 70% and 110% of rated voltage.
- f) 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.

6.7.3. **Spring operated Mechanism**

- 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 close open operation shall be possible with the energy contained in the operating mechanism.
- d) Breaker operation shall be independent of the motor which shall be used solely for compressing the closing spring. Facility for manual charging of the closing spring shall also be provided. The motor rating shall be such that it required preferably not more than 90 seconds for full charging of the closing spring.
- e) Closing action of circuit breaker shall compress the opening spring ready for tripping.
- f) When closing springs are discharged after closing a breaker, closing

springs shall automatically be charged for the next operation and an indication of this shall be provided in the local control cabinet & SAS.

- g) Provisions shall be made to prevent a closing operation of the breaker when the spring is in the partial charged condition.
- h) Mechanical interlocks shall be provided in the operating mechanism to prevent discharging of closing springs when the breaker is in the closed position.
- i) The spring operating mechanism shall have adequate energy stored in the operating spring to close and latch the circuit breaker against the rated making current and also to provide the required energy for the tripping mechanism in case the tripping energy is derived from the operating mechanism.
- 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.

6.7.4. **Hydraulically Operated Mechanism:**

- a) Hydraulically operated mechanism shall comprise of operating unit with power cylinder, control valves, high and low pressure reservoir, motor etc.
- b) The hydraulic oil used shall be fully compatible for the temperature range to be encountered during operation.
- c) The oil pressure switch controlling the oil pump and pressure in the high pressure reservoir shall have adequate no. of spare contacts, for continuous monitoring of low pressure, high pressure etc. at switchyard control room.
- d) The mechanism shall be suitable for at-least two close open operations after failure of AC supply to the motor starting at pressure equal to the lowest pressure of auto reclose duty plus pressure drop for one close open operation.
- e) The mechanism shall be capable of operating the circuit breaker correctly and performing the duty cycle specified under all conditions with the pressure of hydraulic operated fluid in the operating mechanism at the lowest permissible pressure before make up.
- f) Trip lockout shall be provided to prevent operations of the circuit breaker below the minimum specified hydraulic pressure. Alarm contacts for loss of Nitrogen shall also be provided.
- g) All hydraulic joints shall have no oil leakage under the site conditions and joints shall be tested at factory against oil leakage.

6.8. **Controlled Switching Device(CSD):**

- 6.8.1. 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)
 2. Switching of shunt Reactor (From 132, 220, 400 kV side of CB)
- 6.8.2. The CSD shall be provided in 400kV Circuit breakers for controlling transformers and reactors (i.e. 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.
- 6.8.3. 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 specified in Chapter - GTR.
 - 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.
- n) The limit for inrush current for switching of Transformer by CSD shall be 1.0 p.u. of rated current of transformer after fine tuning of CSD settings during pre-commissioning checks. For site acceptance of CSD, during online CSD test after fine tuning, inrush current should be less than 1.0 P.U. of rated current in five consecutive operations.

6.9. The technical parameters of Circuit breakers are as per Annexure –1

6.10. Tests :

6.10.1. Type Tests:

- i. In accordance with the requirements stipulated under Chapter GTR the circuit breaker along with its operating mechanism shall conform to the type tests as per IEC-62271- 100.
- ii. The type test report of Electromagnetic Compatibility Test (EMC) of CSD shall be submitted for approval.
- 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.

6.10.2. Routine Tests:

Routine tests as per IEC: 62271-100 shall be performed on all circuit breakers. In addition to the mechanical and electrical tests specified by IEC, the following shall also be performed.

- i. Speed curves for each breaker shall be obtained with the help of a suitable operation analyzer to determine the breaker contact movement during opening, closing, auto reclosing and trip free operation under normal as well as limiting operating **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 Employer.

- 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.

7. DISCONNECTORS (ISOLATORS)

7.1. 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.

7.2. Construction & Design.

- 7.2.1. 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.
- 7.2.2. 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.
- 7.2.3. 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.
- 7.2.4. It shall be possible to operate the disconnect switches manually by cranks or hand wheels.
- 7.2.5. 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).
- 7.2.6. 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.
- 7.2.7. 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).

- 7.2.8. Remote control of the disconnectors from the control room/SAS shall be made by means of remote/ local transfer switch.
- 7.2.9. 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.
- 7.2.10. 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.
- 7.2.11. 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.
- 7.2.12. 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.
- 7.2.13. 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.
- 7.2.14. 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.
- 7.2.15. All electrical sequence interlocks will apply in both remote and local control modes.
- 7.2.16. 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

- 7.2.17. 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.
- 7.2.18. The disconnecting switches shall be provided with rating plates and shall be easily accessible.
- 7.2.19. The mechanical endurance class shall be M2 as per IEC for 765kV, 400kV 220 kV and 132kV disconnectors.
- 7.2.20. Mechanical position indication shall be provided locally at each disconnector and Electrical indication at each Local Control Cabinet

(LCC) / SAS.

- 7.3. The technical parameters of disconnectors are as per **Annexure-2**

8. SAFETY GROUNDING SWITCHES

- 8.1. 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.
- 8.2. 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.
- 8.3. 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.
- 8.4. The details of the inscription and colouring for the indicator are given as under :

	INSCRIPTION	COLOUR
Open position	OPEN	GREEN
Closed position	CLOSED	RED

- 8.5. Interlocks shall be provided so that manual operation of the switches or insertion of the manual operating device will disable the electrical control circuits.
- 8.6. Each ground switch shall be fitted with auxiliary switches having 4 NO (Normally Open) and 4 NC (Normally Closed) contacts for use by others over and above those required for local interlocking and position indication purposes.
- 8.7. Provision shall be made for padlocking / suitable locking arrangement for the ground switches in either the open or closed position.
- 8.8. 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.
- 8.9. 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.
- 8.10. The safety grounding switches shall conform to the requirements of IEC-62271-102 and shall have electrical endurance class: E0 & shall have mechanical endurance class M2 for 400 kV & M1 for 220/132 kV voltage level.
- 8.11. 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.

- 8.12. Combined Disconnectors & Safety grounding switch arrangement shall also be acceptable.
- 8.13. Mechanical position indication shall be provided locally at each switch and Electrical indication at each Local Control Cabinet (LCC) / SAS.

9. HIGH SPEED MAKE PROOF GROUNDING SWITCHES:

- 9.1. Grounding switches located at the beginning of the line feeder bay modules shall be of the high speed, make proof type and will be used to discharge the respective charging currents, trapped charge in addition to their safety grounding function. These grounding switches shall be capable of interrupting the inductive and capacitive currents and to withstand the associated TRV. These shall conform to class B and electrical endurance class E1 as per annexure – C of IEC : 62271-102
- 9.2. High Speed Grounding switches shall be provided with individual/three pole operating mechanism suitable for operation from DC.
- 9.3. The switches shall be fitted with a stored energy closing system to provide fault making capacity.
- 9.4. 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.
- 9.5. Each high speed make proof grounding switch shall have clearly identifiable local positive driven mechanical indicator together with position indicator on the Local Control Cabinet (LCC) and provision for taking the signal to Control Room/SAS.
- 9.6. The details of the inscription and colouring for the indicator shall be as under:-

	INSCRIPTION	COLOUR
Open position	OPEN	GREEN
Closed position	CLOSED	RED

- 9.7. High speed ground switch operation should be possible locally from Local Control Cabinet (LCC)
- 9.8. These high speed grounding switches shall be electrically interlocked with their associated circuit breakers and disconnectors so that the grounding switches cannot be closed if disconnectors are closed. Interlocks shall be provided so that the insertion of the manual operating devices will disable the electrical control circuits.
- 9.9. Each high speed ground switch shall be fitted with auxiliary switches having 4 NO (Normally Open) and 4 NC (Normally Closed) contacts for use by others, over and above these required for local interlocking and position indication. All contacts shall be wired to terminal blocks in the Local Control Cabinet. Provision shall be made for padlocking the ground switches in their open or closed position.
- 9.10. All portion of the grounding switches and operating mechanism required for connection to ground shall be connected together utilizing copper conductor having minimum cross- sectional area of 100 sq. mm.
- 9.11. The main grounding connection on each grounding switch shall be rated

to carry the peak withstand current rating of the switch for 1 sec. and shall be equipped with a silver plated terminal connector suitable for steel strap of adequate design for connection to the grounding grid.

- 9.12. The high speed make proof grounding switches shall confirm to the requirements of IEC- 62271-102.
- 9.13. 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.

10. INSTRUMENT TRANSFORMERS

10.1. 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.

- 10.1.1. **Ratios and Characteristics:** The CT core distribution for various voltage levels shall be as per Table 3A, 3B, 3C 3D & 3E. Further the numbers of cores, rating, ratios, accuracy class, etc. for the individual current transformers secondary cores shall be in accordance with above table attached at Annexure-3.

Where multi-ratio current transformers are required the various ratios shall be obtained by changing the effective number of turns on the secondary winding.

- 10.1.2. **Rating and Diagram Plates:** Rating and diagram plates shall be as specified in the IEC specification incorporating the year of manufacture. The rated 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.

10.1.3. Constructional Details:

- a) The current transformers incorporated into the GIS will be used for protective relaying and metering purposes and shall be of metal-enclosed type.
- b) Each current transformer shall be equipped with a secondary terminal box with terminals for the secondary circuits, which are connected to the Local Control Cubicle. The star/ delta configuration and the inter connection to the line protection panels will be done at the CT terminal block located in the local control cubicle.
- c) Current transformers guaranteed burdens and accuracy class are to

be intended as simultaneous for all cores.

- d) The rated extended currents for 420 kV class Current transformers shall be as given below:
 - Extended primary current (2000A) – 120% @ 2000/1, 180% @ 1000/1, 200% @ 500/1
 - Extended primary current (4000A) – 120% @ 4000/1, 180% @ 2000/1, 200% @ 1000/1
- e) The secondary winding shall be rated for 2A continuously.
- f) For 245/145/72.5 kV class CTs, the rated extended primary current shall be 120% (or 150% if applicable) on all cores of the CTs as specified in the Chapter – PSR.
- g) For 420/245/145/72.5 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.
- h) For 420/245/145/72.5kV CTs, the instrument security factor at all ratios shall be less than five (5) for metering core. If any auxiliary CTs/reactor are used in the current transformers then all parameters specified shall have to be met treating auxiliary CTs as an integral part of the current transformer. The auxiliary CTs/reactor shall preferably be inbuilt construction of the CTs. In case these are to be mounted separately these shall be mounted in the LCC panel suitably wired upto the terminal blocks.
- i) The wiring diagram, for the interconnections of the three single phase CTs shall be provided inside the Secondary terminal box.
- j) The current transformers shall be suitable for high speed auto-reclosing.
- k) Provisions shall be made for primary injection testing either within CT or outside.
- l) 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.
- m) For 400kV & above voltage class GIS bay module, CT cores shall be duly distributed on both sides of the circuit breaker. For 220 kV and below voltage level GIS bay module, CT on one side of the circuit breaker is also acceptable.

10.2. 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.

10.2.1. **Ratios and Characteristics:** The rating, ratio, accuracy class,

connection etc. for the voltage transformers shall be in accordance with Annexure 4 & Table 4A.

- 10.2.2. **Rating and diagram plates** :Rating and diagram plate shall be provided complying with the requirements of the IEC specification incorporating the year of manufacture and including turns ratio, voltage ratio, burden, connection diagram etc.

10.2.3. **Secondary Terminals, Earthing**

The beginning and end of each secondary winding shall be wired to suitable terminals accommodated in a terminal box mounted directly on the voltage transformer section of the SF6 switchgear.

All terminals shall be stamped or otherwise marked to correspond with the marking on the diagram plate. Provision shall be made for earthing of the secondary windings inside the terminal box.

- 10.2.4. The transformer shall be able to sustain full line to line voltage without saturation of transformer.

10.2.5. **Constructional Details of Voltage Transformers :**

- a) The voltage transformers shall be located as a separate bay module and will be connected phase to ground and shall be used for protection, metering and synchronization.
- b) The voltage transformers shall be of inductive type, nonresistant and shall be contained in their own-SF6 compartment, separated from other parts of installation. The voltage transformers shall be effectively shielded against high frequency electromagnetic transients. The supplier shall ensure that there is no risk of Ferro resonance due to the capacitance of the GIS.
- c) The voltage transformers shall have three secondary windings.
- d) Voltage transformers secondary shall be protected by Miniature Circuit breakers (MCBs) with monitoring contacts for all the windings. The secondary terminals of the VT's shall be terminated to preferably stud type non-disconnecting terminal blocks in the secondary boxes via the fuse.
- e) The voltage transformer should be thermally and dielectrically safe when the secondary terminals are loaded with the guaranteed thermal burdens.
- f) The accuracy of 0.2s on secondary III should be maintained throughout the entire burden range up to 50 VA on all the three windings without any adjustments during operation.
- g) The diagram for the interconnection of the VTs shall be provided inside secondary terminal box.
- h) It should be ensured that access to secondary terminals is without any danger of access to high voltage circuit.

10.3. **Tests:**

- 10.3.1. In accordance with the requirements in Chapter-GTR, Current Transformer and Voltage Transformer should have been type tested and shall be subjected to routine tests in accordance with relevant IEC.
- 10.3.2. 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

11. SURGE ARRESTORS

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

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

The contractor shall perform all necessary studies and the report shall detail the limits of all equipment parameters which could affect the insulation co-ordination. The report shall also detail the characteristics of the surge arrestor and shall demonstrate that the selected arrestor's protective and withstand levels, discharge and coordinating currents and arrestor ratings and comply with the requirement of this specification.

The contractor shall also consider in the studies the open circuit breaker condition, fast transients generated by slow operation of disconnecting switches. The study report and design calculations shall be submitted for Owner's approval.

11.3. Duty requirements of GIS Surge Arrestor

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

11.3.2. Surge arrestor shall be disconnect-link type and be attached to the gas-insulated system in such a manner that they can be readily disconnected from the system while the system is being dielectrically tested.

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

11.3.4. 420kV class arrester shall be capable of discharging energy equivalent to **Station High Duty (SH) class of IEC with thermal energy (Wth) of 12 kJ/kV for a 420kV system** followed immediately by 50 Hz energization with a sequential voltage profile as specified below:

650 kVp for 3 peaks

575 kVp for 0.1 second

550 kVp for 1 second

475 kVp for 10 seconds

11.3.5. 245/145/72.5 kV class arrester shall be capable for discharging energy equivalent to **Station Medium Duty (SM) class of IEC with thermal energy (Wth) of minimum 7 kJ/kV for 245/145/72.5 kV system** followed by procedure as per IEC.

11.3.6. The reference current of the arresters shall be high enough to eliminate the influence of grading and stray capacitance on the measured reference voltage.

11.3.7. The surge arresters are being provided to protect the followings whose insulation levels are indicated in the table given below:-

Equipment to be protected	400kV system		220KV system	132KV system	132KV system	66KV system
	Lightning impulse (kVp)	Switching surge (kVp)	Lightning impulse (kVp)	Lightning impulse (kVp)	Lightning impulse (kVp)	Lightning impulse (kVp)
Power Transformer	± 1300	± 1050	± 950	± 550	± 550	± 250
Instrument Transformer	± 1425	± 1050	± 1050	± 650	± 650	± 325
Reactor	± 1300	± 1050	-	-	-	-
CB/Isolator Phase to ground	± 1425	± 1050	± 1050	± 650	± 650	± 325
CB/Isolator Across open contacts	± 1425 (-/+240)	± 900 (-/+345)	± 1200	± 750	± 750	± 375

11.3.8. **Constructional Features**

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

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

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

11.4. **Tests**

- 11.4.1. In accordance with the requirements stipulated, the surge arrestors shall conform to type tests and shall be subjected to routine and acceptance tests in accordance with IEC document.
- 11.4.2. Each metal oxide block shall be tested for the guaranteed specific energy capability in addition to the routine/acceptance test as per IEC-60099.
- 11.4.3. Test on Surge Monitors: The Surge monitors shall also be connected in series with the test specimens during residual voltage and current impulse withstand tests to verify efficacy of the same. Additional routine/functional tests with one 100A and 10 kA current impulse, (8/20 micro sec.) shall also be performed on the surge monitor.
- 11.5. **Technical Parameters:** Technical parameters are as per Annexure 5.

12. OUTDOOR SF6/Air BUSHINGS:

Outdoor bushings, for the connection of conventional external conductors to the SF6 metal enclosed switchgear, shall be provided where specified and shall conform to the requirements given in GTR.

The dimensional and clearance requirements for the metal enclosure will be the responsibility of the manufacturer and their dimensions must be coordinated with the switchgear.

Bushings shall generally be in accordance with the requirements of IEC -60137.

- 12.1. Insulation levels and Creepage distances: All bushings shall have an impulse and power frequency withstand level that is greater than or equal to the levels specified for GIS.

The creepage distance over the external surface of outdoor bushings shall not be less than 25 mm/kV and in highly polluted area it shall not be less than 31mm/kV (as per Chapter- PSR).

- 12.2. **Bushing types and fitting:** The details of bushing shall be as follows

SF6 to air Bushing shall be of Polymer / composite type and shall be robust and designed for adequate cantilever strength to meet the requirement of seismic condition, substation layout. The electrical and mechanical characteristics of bushings shall be in accordance with IEC: 60137. All details of the bushing shall be submitted for approval and design review.

Polymer / composite insulator shall be seamless sheath of a silicone rubber compound. The housing & weather sheds should have silicon content of minimum 30% by weight. It should protect the bushing against environmental influences, external pollution and humidity. The hollow silicone composite insulators shall comply with the requirements of the IEC publications IEC 61462 and the relevant parts of IEC 62217. The design of the composite insulators shall be tested and verified according to IEC 61462.

- 12.3. **Mechanical forces on bushing terminals:** Outdoor bushings must be capable of withstanding cantilever forces due to weight of bus duct (GIB) on one side & AIS conductor/Al tube on the other side and short circuit forces.
- 12.4. Type test reports as per applicable IEC including radio interference voltage (RIV) test shall be submitted in line with the requirement as specified in Chapter GTR for approval.
- 12.5. The technical parameters of Bushing are as per **Annexure-6**

13. GIS TO CABLE TERMINATION (If applicable)

- 13.1. This scope covers the supply, erection, commissioning of connection assembly of fluid- filled or extruded cables to gas-insulated metal enclosed switchgear (GIS) as per IEC 62271-209
- 13.2. The XLPE cables shall be connected to GIS by the interfacing of XLPE cable sealing end to GIS Cable termination enclosure.
- 13.3. The GIS to XLPE cable termination shall conform to IEC-62271-209.
- 13.4. The rating of XLPE cables for different voltages is specified in the Chapter PSR.
- 13.5. The limits of supply of gas-insulated metal-enclosed switchgear and the cable termination shall be in accordance with IEC 62271-209.
- 13.6. 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.
- 13.7. The SF6 cable end unit and connection support structure should be equipped with provisions for isolating the cable sheath or pipe to permit cathodic protection of cable system.(see IEC62271-209)
- 13.8. 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.
- 13.9. 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.
- 13.10. 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.

14. TRANSFORMER / REACTOR TERMINATION**14.1. TRANSFORMER / REACTOR Direct Connection with GIS (if applicable)**

- 14.1.1. 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.
- 14.1.2. 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.
- 14.1.3. 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.

- 14.1.4. 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.

14.2. TRANSFORMER / REACTOR Connection with SF6/Air Bushing

- 14.2.1. 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.
- 14.3. 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 Chapter PSR.

15. LOCAL CONTROL CUBICLE (LCC)

15.1. Functions

- 15.1.1. 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.
- 15.1.2. Status indications in the LCC shall be semaphore type or LED type.
- 15.1.3. 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.
- 15.1.4. If Disconnecter or earth switch is not in the fully open or closed position a "Control Circuit Faulty" alarm shall be initiated, and electrical operation shall be blocked.
- 15.1.5. 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 .
- 15.1.6. 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.
- 15.1.7. 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.

- 15.1.8. 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

15.2. Constructional features

- 15.2.1. Local Control cubicle shall be either mounted on the GIS with front access or free standing, floor mounting type. It shall comprise structural frames completely enclosed with specially selected smooth finished, cold rolled sheet steel of thickness not less than 3 mm for weight bearing members of the panels such as base frame, front sheet and door frames, and 2.0mm for sides, door, top and bottom portions. There shall be sufficient reinforcement to provide level transportation and installation. Alternatively folded sheet panels of adequate thickness and strength is also acceptable.
- 15.2.2. 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/PU gaskets conforming to the provision of IS 11149/ ISO 4633/ASTM F 104 /ASTM D2000. However, XLPE gaskets can also be used for fixing protective glass doors.
- 15.2.3. 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.
- 15.2.4. 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 IEC 60269 mounted on plug-in type fuse bases. The short time fuse rating of Fuses shall be not less than 9 KA. Fuse carrier base shall have imprints of the fuse 'rating' and 'voltage'.
- 15.2.5. 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 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.
- 15.2.6. Operating mechanisms, auxiliary switches and associated relays, control switches, control cable terminations, and other ancillary equipment shall

be accommodated in sheet steel vermin proof cubicles.

- 15.2.7. 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.
- 15.2.8. 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.
- 15.2.9. 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.
- 15.2.10. 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.
- 15.2.11. 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.
- 15.2.12. 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.-
- 15.2.13. 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.
- 15.2.14. 400kV Circuit Breaker control schematics shall be finalized in such a way, that it may operate with or without CSD by using a suitable selector switch irrespective of whether circuit breakers to be supplied are envisaged along with CSD or not as per bid price schedules.

15.3. Cabling between LCC Panel and GIS equipment

- 15.3.1. The unarmored screen cable shall be of 1.1kV grade, multi core, annealed copper conductor, Tinned copper braided screen (approx. 85% coverage).
- 15.3.2. The core insulation and outer sheath of cable shall be of halogen-free special polymer.
- 15.3.3. The cable shall be flame-retardant, flexible, abrasion-and wear-resistant.

- 15.3.4. 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.
- 15.3.5. Prefabricated cables with heavy duty multi-point plug-in connections on GIS end shall be provided.
- 15.3.6. All instrument transformer connections shall be hard wired to terminal block via ring type connection.

16. GIS BUILDING

- 16.1. 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 Chapter PSR.
- 16.2. 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.
- 16.3. 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 Chapter PSR/BPS.
- 16.4. 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. The layout for GIS Building(s) is indicated in the drawings. The layout 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.
- 16.6. 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 as per clause 16.1 shall be accommodated in the above room. The panel room shall be air-conditioned. Further, the temperature of the room shall be monitored through substation automation system by providing necessary temperature transducers.

17. ELECTRIC OVERHEAD CRANE :

- 17.1. One EOT cranes for 400/220/132 kV GIS hall of suitable capacity shall be provided for erection & maintenance of largest/heaviest GIS component/assembly. The crane shall consist of all special requirements for erection & maintenance of GIS equipment.
- 17.2. The capacity of the crane shall be sized to lift the heaviest GIS switchgear component.
- 17.3. The Crane shall be used for the erection and maintenance of the GIS switchgear components 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.
- 17.4. Crane hook approaches shall be of the minimum possible dimensions

- to ensure maximum coverage of the GIS building area.
- 17.5. The crane(s) shall be capable of lifting and accurately positioning all loads ranging from full crane rated capacity to at least 10% rated capacity.
- 17.6. Crane shall be designed for operation under following variable speeds through VVVF drives at full load :
- Hoisting: 0.3 – 3 Meters per
Minute Cross Travel: 1.6 – 16
Meters per Minute Long Travel:
2.0 – 20 Meters per Minute
- 17.7. The electric overhead cranes shall be provided with walkways, platforms. 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.
- 17.8. The platform and walkways shall be designed to support any weight to be imposed upon them during crane overhaul.
- 17.9. An access platform shall be provided together with a guarded ladder to allow access to the bridge rails.
- 17.10. The crane shall be provided with pendant control and RF control.
- 17.11. Contractor shall submit the capacity calculation of crane for GIS hall considering a factor of safety of rope as at least 5.
- 17.12. The Capacity of Cranes to be provided for GIS Hall shall confirm following.
- a) The crane for 400kV GIS hall shall have capacity of minimum 10T safe working load & minimum hook height of crane have shall be 9.0 meters or as per actual requirement whichever is higher.
- b) The crane for 220kV GIS/132kV GIS/66kV GIS shall have capacity of minimum 6T safe working load & minimum hook height of crane have shall be 8.0 meters or as per actual requirement whichever is higher.
- 17.13. In case the GIS hall is to be extended, the scope of work also involves extension of EOT crane girders and all necessary Electrical & Mechanical accessories to facilitate movement of existing EOT crane in the extended portion of GIS hall. Cost of the same shall be deemed to be covered in the building cost.
- 17.14. The following tests shall be carried out on EOT Crane.
1. The crane shall be tested at manufacturer work under full load and 25 percent overload of hoisting and cross transverse motions as a routine test.
 2. Further the following tests may be done at site after installation of the crane at site
 - a. Check all the accessories for proper function
 - b. No load test
 - c. Load test as per site conditions

18. SEISMIC DESIGN CRITERIA:

- 18.1. The equipment shall be designed for operation in seismic zone for earthquake resistance. The seismic loads are due to the horizontal and vertical acceleration which may be assumed to act on concurrently. Seismic Qualification requirements shall be as per IEC 62271-207 for the design of equipment. The equipment along with its parts shall be strong enough and sufficiently well connected to resist total operating stresses resulting from the forces in normal operation, but in case of abnormal condition shall also resist with forces superimposed due to earthquakes. Test Report/Analysis Report should be furnished.

19. DESIGN REVIEW

- 19.1. Design reviews shall be conducted by Employer; however the entire responsibility of design shall be with the supplier.
- 19.2. Employer may also visit to the supplier's works to inspect design, manufacturing and test facilities.
- 19.3. The design review will commence after placement of award with the successful contractor and shall be 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.
- 19.4. The design review shall be conducted generally following the, "User Guide for the application of Gas Insulator Switchgear (GIS) rated voltage of 72.5kV and above" – CIGRE report No. 125 prepared by CIGRE Working Group 23.10.
- 19.5. The manufacturer will be required to demonstrate the use of adequate safety margins for thermal, mechanical, dielectric, insulation coordination and vibration etc. design to take into the account the uncertainties of his design and manufacturing processes.
- 19.6. The scope of such a design review shall at least include the following:

1.	Dielectric Stress of Solid Insulation like Gas Barrier, support insulator etc.
2.	Dielectric stress of SF ₆ Gas Volume.
3.	Mechanical strength of enclosure, expansion joints etc.
4.	Criteria for providing expansion joint.
5.	Sealing system
6.	Insulation coordination
7.	Thermal stress and resulting increase in gas pressure during short circuit condition.
8.	Earthing of enclosure w.r.t circulating current.
9.	Seismic design, as per IEC 62271-207
10.	Circuit Breaker.
11.	Isolator and Earth switch.
12.	Voltage transformer.
13.	Current Transformer.
14.	Surge Arrester.
15.	Bushing.
16.	Ducting.
17.	Corrosion protection.

18.	Electrical and physical Interfaces with substation.
19.	Testing capabilities.
20.	Inspection and test plan.
21.	Transport and storage.
22.	Maintainability.
23.	Site Test.

19.7. Further, the manufacturer shall furnish the following information 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 as per clause no 5.41.
- 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.

20. TYPE TESTS

The offered GIS equipment shall conform to the type tests as per IEC-62271-203. Contractor shall submit type test reports for the following type tests & additional type tests.

Sl.	Description of the Type Test for GIS
1	Tests to verify the insulation level of the equipment and dielectric test on auxiliary circuits
2	Tests to prove the temperature rise of any part of the equipment and measurement of the resistance of the main circuit
3	Tests to prove the ability of the main and earthing circuits to carry the rated peak and rated short time withstand current
4	Tests to verify the making and breaking capacity of the included switching devices
5	Tests to prove the satisfactory operation of the included switching devices
6	Tests to prove the strength of the enclosures
7	Gas tightness tests
8	Tests on partitions
9	Tests to prove the satisfactory operation at limit temperatures
10	Tests to assess the effects of arcing due to internal fault
11	Verification of the degree of protection of the enclosure
12	Tests to prove performance under thermal cycling and gas tightness tests on insulators

13	Additional tests on auxiliary and control circuits
14	Reactor current switching test for Inductive Current switching capability as per IEC 62271-110. Further, the manufacturer whose circuit breakers tested with smaller current w.r.t current limits specified for Reactor current switching test duty-2, 3 & 4 in IEC 62271-110 shall also be acceptable.
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

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 Chapter-GTR, Technical Specification.

21. MISCELLANEOUS

- 21.1. **Painting of enclosure:** All enclosures shall be painted externally as per manufacturer's painting procedure.
- 21.2. **Heaters:** Wherever required, heaters shall be provided to prevent moisture condensation inside various Marshaling boxes.
- 21.3. **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.

22. TRANSPORT OF EQUIPMENT TO SITE

The contractor shall be responsible for the loading, transport, handling and offloading of all equipment and materials from the place of manufacture or supply to site. The contractor shall be responsible to select and verify the route, mode of transportation and make all necessary arrangement with the appropriate authorities as well as determining any transport restrictions and regulations imposed by the government and other local authorities. All transport packages containing critical units viz Circuit breakers and Voltage transformers shall be provided with sufficient number of 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.

23. PACKING, STORAGE AND UNPACKING

- 23.1. All the equipment shall be carefully packed for transport by sea, rail and

road in such a manner that it is protected against the climatic conditions and the variations in such conditions that will be encountered enroute from the manufacturer's works to the site.

- 23.2. The SF6 metal clad equipment shall be shipped in the largest factory assembled units that the transport and loading limitations and handling facilities on site will allow to reduce the erection and installation work on site to a minimum.
- 23.3. Where possible all items of equipment or factory assembled units shall be boxed in substantial crates or containers to facilitate handling in a safe and secure manner. Should the units be considered too large for packing in crates, they shall be suitably lagged and protected to prevent damage to any part, particularly small projections, during transport and handling. Special lugs or protective supports shall be provided for lifting to prevent slings and other lifting equipment from causing damage. Each crate, container or shipping unit shall be marked clearly on the outside to show where the weight is bearing and the correct position for the slings.
- 23.4. Each individual piece to be shipped, whether crate, container or large unit, shall be marked with a notation of the part or parts contained therein.
- 23.5. Special precautions shall be taken to protect any parts containing electrical insulation against the ingress of moisture. This applies particularly to the metal clad equipment of which each gas section shall be sealed and pressurized prior to shipping. Either dry nitrogen/air or dry SF6 gas shall be used and the pressure shall be such as to ensure that, allowing for reasonable leakage, it will always be greater than the atmospheric pressure for all variations in ambient temperature and the atmospheric pressure encountered during shipment to site and calculating the pressure to which the sections shall be filled to ensure positive pressure at all times during shipment.
- 23.6. 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 Employer. **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.
- 23.7. Valves and other gas couplings associated with the switchgear gas systems shall be adequately protected against damage from any bumps or physical blows. They shall also be capped to prevent ingress of dirt or moisture or damage to any coupling, pipes, threads or special fittings. Any explosion vents and other pressure relief devices, shall be suitably sealed and protected to prevent accidental exposure of the sealed sections during shipment to site.

- 23.8. For bus ducts involving male and female joints of the current carrying conductor, the same shall be transported in disassembled condition to avoid any damage during transit. All bright parts liable to rust shall receive a coat of anti rusting composition and shall be suitably protected.
- 23.9. The contractor 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.
- 23.10. 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.
- 23.11. 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 etc.) for each voltage level. Thereafter proper re-packing of the GIS unit shall be ensured as per manufacturer recommendation.

24. INSTALLATION OF GIS

- 24.1. 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. The GIS Hall needs to be in positive pressure before starting Installation.
- 24.2. 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 Employer.
- 24.3. 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.
- 24.4. All assembly work shall be done by qualified personnel only who are to be identified and list submitted to Employer site before starting of erection work.
- 24.5. Assembly drawing for GIS erection for the section under progress shall be available and displayed in GIS hall at the time of erection work.
- 24.6. 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.
- 24.7. GIS hall door shall have automatic close facility after entry of personnel

to avoid dust and moisture entry. Walls and ceiling shall be in a condition so that neither dirt nor plaster might fall or rub off and formation of condensation water in ceiling shall be prevented under any circumstances.

- 24.8. 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.
- 24.9. Only T&P and consumables required for GIS erection shall be kept in GIS during erection.
- 24.10. 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)
- 24.11. 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.
- 24.12. 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 Employer 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.
- 24.13. 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.
- 24.14. All Civil Work inside building including internal cable trench shall be completed before GIS installation.
- 24.15. 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.
- 24.16. O Rings shall be properly stored and taken out only before installation. O Rings are also to be cleaned before use with manufacturer authorized cleaning agent.
- 24.17. At all points of time during installation authorized personnel shall use suitable gloves to avoid contamination.
- 24.18. 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.
- 24.19. Field Quality Plan shall be approved from Employer and shall be followed during site work.

25. 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 test shall be submitted by contractor in advance.

26. MANDATORY SPARE

Design, engineering, manufacture, testing, supply on FOR destination site basis including transportation & insurance, storage at site of Mandatory spares for the GIS (As specified in BPS).

1. Any equipment not supplied as main equipment or part of main equipment does not require mandatory spares.
2. It is acknowledged that the GIS manufacturer may have standardized the GIS design or equipment rating based on their standard practices. Alternate proposals offering higher-rated equipment (without additional cost) will be considered, provided they meet the specified minimum design ratings, standards, and performance requirements. If the contractor offers circuit breakers, dis-connectors, current transformers, SF6/Air Bushings, etc., under the main equipment with a higher rating than specified, the mandatory spares must also be of the same higher rating and identical to the main equipment offered. These spares must be supplied without any additional cost to Employer.

27. TESTING & MAINTENANCE EQUIPMENT

Testing & Maintenance equipment shall be offered, as per relevant schedule of BPS.

27.1. SF6 Gas leakage detector.

- a) The detector shall be portable, battery operated, hand held type and having a minimum SF6 gas leakage sensitivity of 5gm/year. The sensor shall be connected through a flexible wand for easy accessibility to joints, seals and couplings in GIS equipment and provided with a protection filter. The equipment shall have on/off switch & suitable indicating lamps/LEDs, variable pitch audible signal for leakage indication. 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.

27.2. Gas filling and evacuating plant: (Gas Processing unit)

- b) 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).
- c) 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.

- d) The minimum capacity parameters of evacuation plant will be as under:
- | | |
|-----------------------------------|--------------------------|
| Oil Free Suction (Recovery) Pump: | 30 M ³ /Hour |
| Compressor (Two Stage): | 15 M ³ /Hour |
| Oil Free Vacuum Pump: | 100 M ³ /Hour |
- e) 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

27.3. SF6 gas analyzer:

The SF6 gas analyzer should be of portable type and instruments shall have following features:

- a) In-built calibration facility.
- b) Sensitivity of the equipment shall not be affected by any atmospheric conditions like dust, humidity, heat, wind etc.
- c) Equipment shall work on zero gas loss principle i.e. gas should be pumped back to the compartment after measurement without any exposure to the atmosphere.
- d) Equipment shall be supplied with suitable regulator which can be used to connect SF6 cylinder if required.
- e) Following acidic/impurities products should be detected as per IEC 60480 and IEC 60376
 - i) SF6 purity – Range: 0-100 % & Accuracy: +/- 2 deg
 - ii) Dew point - Range : -60 to +20 deg C & Accuracy: +/- 4 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
- g) Input pressure: upto 10 bar
- h) It should be housed in a robust IP67 case with wheels

27.4. Portable Partial Discharge (PD) monitoring system (Shall generally applicable for 220kV&132 kV)

- a) The equipment shall be used for detecting different types of defects in Gas Insulated Stations (GIS) such as Particles, Loose shields and Partial Discharges as well as for detection of Partial discharges in other types of equipment such as Cable Joints, CTs and PTs.
- b) It shall be capable for measuring PD in charged GIS environment as EHV which shall have bandwidth in order of 100 MHz–2GHz with possibility to select a wide range of intermediate bandwidths for best measurement results. The principle of operation shall be based on UHF principle of detection. The instrument should also be able to detect partial discharges in cable joints and terminations.
- c) Detection and measurement of PD and bouncing particles shall be displayed on built in large LCD display and the measurement shall be stored in the instrument and further downloadable to a PC for further analysis to locate actual source of PD such as free conducting particles, floating components, voids in spacers, particle on spacer surfaces etc.

Software for display and diagnosis of PD signals and an expert software system for accurate interpretation of cause of PD shall also be supplied and installed by the contractor.

- d) The equipment shall meet the following requirements
1. Measurement shall be possible in noisy environment.
 2. Stable reading shall be possible in presence of vibrations within complex GIS assemblies, which can produce signals similar to PD.
 3. Equipment should have necessary synchronizing circuits to obtain PD correlation with power cycle and power frequency.
 4. The equipment shall be battery operated with built-in-battery charger. It shall also be suitable for 230V AC/50 Hz input.
 5. Measurement shall be possible in the charged switchyard in the presence of EMI/EMC. Supplier should have supplied similar detector for GIS application to other utilities. Performance certificate and the list of users shall be supplied along with the offer.
 6. Instrument shall be supplied with standard accessories i.e., re-locatable sensors with mounting arrangements, connecting cables (duly screened) to sensors, Lap-top PC, diagnostic and expert interpretation software, carrying case, rechargeable battery pack with charger suitable for 230V AC, 50Hz supply connecting cables (duly screened) to view in storage.
 7. The function of software shall be covering the following:
 - i. Data recording, storage and retrieval in computer
 - ii. Data base analysis
 - iii. Template analysis for easy location of fault inside the GIS
 - iv. Evaluation of PD measurement i.e, Amplitude, Phase Synchronization etc.
 - v. Evaluation of bouncing/loose particles with flight time and estimation on size of particle.
 - vi. Expert software system for accurate interpretation of cause of PD.
 - vii. Report generation.
 8. To prove the suitability in charged switchyard condition, practical demonstration shall be conducted before acceptance.
 9. Supplier shall have "Adequate after sales service" facility and shall provide the document in support of this.
 10. Necessary training may be accorded to personnel to make use of the kit for locating PD sources inside the GIS
 11. Instrument shall be robust and conform to relevant standard.
- e) **Calibration:** The UHF Couplers have to be first calibrated as per CIGRE Document No. 654 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.

- f) Pulse generator, same type as that of used during factory testing for UHF sensor sensitivity test shall be supplied as a standard accessory.

27.5. Online Partial Discharge Monitoring System (Applicable for 400 kV GIS)

- a) 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.
- b) 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 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.
- c) 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.
- d) 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 Server 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. The workstation PC Server shall be powered by suitable dedicated UPS and same is included in the present scope.

The PC Work Station Monitor (32" LED type of reputed make), Keyboard and Mouse shall be placed in Control room with necessary provision for its connection with PDM server.

- e) 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.
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 substation. 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.
- f) **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.
- g) **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.
- h) **Computers and Peripherals:** The PC operating system shall be the latest version of MS Windows with end user license. 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 with 16 GB RDIMM, 3200MT/s RAM or better and retrievable hard disk drive of 1TB as specified shall be available in the substation.
- i) **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.

- j) **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.
- k) **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.
- l) **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.
- m) **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.
- n) **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.
- o) **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.
- p) **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.

- q) **Print Option/Facility:** PDM system should have the option/facility of printing all trend plots/reports/POW patterns/displays, etc and it shall be capable of printing directly to Laser Colour printer available at substation control room.
- r) **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.
- s) **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
- t) **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 pen drive.

Pulse generator for UHF sensor sensitivity test shall also be supplied as a standard accessory.
- u) **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.
- v) **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.
- w) **List of References:** The bidder shall provide a reference list of PD monitoring system, which is supplied by them and in successful operation worldwide in a power utility.

28. Support Services

Throughout design, implementation, factory testing, and field installation and testing, the Contractor shall supply consulting assistance, as required by the Employer for site preparation, field installation, and other areas where technical support may be required. The Contractor shall be responsible for minor facility renovation, and maintenance of the supplied system up to and including successful completion of the Site Acceptance Test. After final acceptance of the GIS equipment, the Contractor shall offer continuing technical support and spare parts up to 5 years.

Consultation with Contractor's technical support personnel and trained field service personnel shall be readily available on a short-term/long-term basis to assist the Employer personnel in maintaining, expanding, and enhancing the GIS System upon expiration of the defect liability period. The Contractor shall include in their offer(s), a proposal for ensuring continued technical support as stated above.

ANNEXURE-1
TECHNICAL PARAMETERS FOR CIRCUIT BREAKER

Sl.No.	Parameter	400kV system	220kV system	132 kV system	66 kV system
1.	Rated voltage (U _{max}) kV (rms)	420	245	145	72.5
2.	Rated frequency (Hz)	50	50	50	50
3.	No. of poles	3	3	3	3
4.	Type of circuit breaker	SF6 gas insulated	SF6 gas insulated	SF6 gas insulated	SF6 gas insulated
5.	Rated continuous current (A) at an ambient temperature of 50°C	As per BPS	As per BPS	As per BPS	As per BPS
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	40kA
7.	Symmetrical interrupting capability kA (rms)	63	50	40	40
8.	Rated short circuit making current kAp	157.5	125	100	100
9.	Short time current carrying capability kA (rms)	63 for one second	50 for one second	40 for one second	40 for one second
10.	Out of phase breaking current carrying capability kA (rms)	15.75	As per IEC	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	As per IEC
12.	First pole to clear factor	1.3	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	As per IEC: 62271-100
14.	Rated break time as IEC (ms)	40	60	60	60
15.	Total break time (ms)	45	65	65	65
16.	Total closing time (ms)	Not more than 150	Not more than 150	Not more than 150	Not more than 150
17.	Operating mechanism or a combination of these	Spring	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	O-0.3s- CO-3 min-CO

Sl.No.	Parameter	400kV system	220kV system	132 kV system	66 kV system
19.	Reclosing	Single phase & Three phase auto reclosing.	Single phase & Three phase auto reclosing.	Three phase auto reclosing. (Single phase auto reclosing if specified in Chapter-PSR)	Three phase auto reclosing. (Single phase auto reclosing if specified in Chapter-PSR)
20.	Pre-insertion resistor requirement	As per BPS	NA	NA	NA
i)	Rating (ohms)	400(max.) with tolerance as applicable	NA	NA	NA
ii)	Minimum electrical (mechanical insertion time + pre-arcing time) pre-insertion time (ms)	8	NA	NA	NA
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)	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	As per IEC
23.	Trip coil and closing coil voltage with variation as specified	220V DC	220V DC	220V DC or 110V DC	220V DC or 110V DC
24.	Noise level at base and up to 50 m distance from base of circuit breaker	140dB (max.)	140dB (max.)	140dB (max.)	140dB (max.)
25.	Rating of Auxiliary contacts	10A at 220V DC	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	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	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 kVp power frequency	1050 kVp	+ 650kVp	+ 325kVp

Sl.No.	Parameter	400kV system	220kV system	132 kV system	66 kV system
		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	NA
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	NA
v)	One minute power frequency dry withstand voltage between line terminals and ground	520 kV rms.	460 kV rms.	275 kV rms	140 kV rms
vi)	One minute power frequency dry withstand voltage between terminals with circuit breaker open	610 kV rms.	460 kV rms.	275 kV rms	160 kV rms
28.	Minimum corona extinction voltage with CB in all positions	320kV rms	156 kV rms	92 kV rms	NA
29.	Max. radio interference voltage for frequency between 0.5 MHz and 2 MHz (Micro volts)	1000 μ V (at 266kV rms)	1000 μ V (at 156kV rms)	500 μ V (at 92kV rms)	NA
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.			
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			

ANNEXURE-2**TECHNICAL PARAMETERS FOR DISCONNECT SWITCH/ ISOLATORS**

Sl. No	Particulars	400 kV	220 kV	132kV	66kV
1.	Rated voltage (rms) Un	420 kV	245 kV	145 kV	72.5 kV
2.	Rated frequency	50 HZ	50 HZ	50 Hz	50 Hz
3.	System earthing	Effectively earthed	Effectively earthed	Effectively earthed	Effectively earthed
4.	Type	SF6 insulated	SF6 insulated	SF6 insulated	SF6 insulated
5.	Rated continuous current (A) at 50°C ambient temp.(as applicable)	As per BPS	As per BPS	As per BPS	As per BPS
6.	Rated short time withstand current of isolator and earth switch(as applicable)	63 kA for 1 Sec.	50 kA for 1 Sec.	40 kA for 1 second	40 kA for 1 second
7.	Rated dynamic short circuit withstand current of isolator and earth switch(As applicable)	157.5 kAp	125 kAp	100 kAp	100 kAp
8.	Rated insulation level:				
	One minute power freq. Withstand voltage: To earth:	650 kV rms.	460 kV rms.	275 kV rms.	140 kV rms.
	One minute power freq. Withstand voltage: Across isolating distance	815 kV rms.	530 kV rms.	315 kV rms.	160 kV rms.
	1.2/50 micro sec. Lighting impulse withstand voltage (+ve or -ve polarity) To earth:	1425 kVp	±1050 kVp		
	1.2/50 micro sec. Lighting impulse withstand voltage (+ve or -ve polarity) : Across Isolating distance	±1425/-+240 kVp	±1200 kVp		

Sl. No	Particulars	400 kV	220 kV	132kV	66kV
	Rated switching impulse withstand voltage (250/2500 micro-sec.) Dry & wet :between line terminals and ground:	+/- 1050 kVp	N.A		
	Rated switching impulse withstand voltage (250/2500 micro-sec.) Dry & wet :Between terminals with Isolator open:	+/- 900 kVp impulse on one terminal & 345 kVp of opposite polarity on the other terminal.	N.A		
9.	Mechanical Endurance clause as per IEC	M2	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	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	4 NO and 4 NC

ANNEXURE-3

TECHNICAL PARAMETERS FOR CURRENT TRANSFORMERS

S. No.	Description	400kV system	220kV system	132/66 kV system
1	Rated voltage, U_m (kVrms)	420	245	145/72.5
2	Rated frequency (Hz)	50	50	50
3	No. of Poles	1	1	1
4	Design ambient temperature (°C)	50	50	50
5	Rated Primary Current (A)	As per BPS	As per BPS	As per BPS
6	Rated extended primary current	120% to 200%	120%/150%	120%/150%
7	Rated short time thermal withstand current	63k A for 1 sec	50kA for 1 sec	40kA for 1sec
8	Rated dynamic current	157.5kAp	125k Ap	100kAp
9	Temperature rise over design ambient temperature	As per IEC		
10	Rated Insulation levels			
a)	Full wave impulse withstand voltage (1.2/50 microsecond)			
i)	between line terminals and ground(kVpeak)	±1425	±1050	±650/± 325
b)	Switching impulse withstand voltage (250/2500 microsecond) (dry and wet)			
i)	between line terminals and ground (kVpeak)	± 1050	-NA-	-NA-
c)	One minute power frequency dry withstand voltage (dry and wet)			
i)	between line terminals and ground (kVrms)	630 (dry only)	460	275/140
d)	One minute power frequency withstand voltage between secondary terminals & earth (kVrms)	5kV		
11	Max. radio interference voltage for frequency between 0.5 MHz and 2 MHz at (microvolts)	1000 at 266kV rms	1000 at 156kV rms	500 at 92kV rms/NA
12	Minimum Corona extinction voltage (kVrms)	320	-NA-	-NA-
13	Seismic acceleration (Horizontal)	As per PSR	As per PSR	As per PSR
14	Partial Discharge	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.		
17	System neutral earthing	Effectively Earthed		

For other parameters, refer respective Table for the applicable voltage class of CTs.

TABLE-3A**REQUIREMENTS FOR 400 kV CURRENT TRANSFORMER**

No. of cores	Core No.	Application	Ratio	Output Burden	Accuracy Class	Min. Knee Pt. Voltage (Vk)	Max. CT Sec. wdg. Resistance (in Ω)	Max. Excit. Current at Vk (in mA)
6	1	BUS DIFF. CHECK	4000/ 2000/ 1000/1	-	PX	4000/ 2000/ 1000	15/10/5	20 on 4000/1 TAP; 30 on 2000/1; 60 on 1000/1 tap
	2.	BUS DIFF. MAIN	4000/ 2000/ 1000/1	-	PX	4000/ 2000/ 1000	15/10/5	20 on 4000/1 TAP; 30 on 2000/1; 60 on 1000/1 tap
	3.	METERING	4000/ 2000/ 1000/1	20 20 20	0.2S 0.2S 0.2S	- - -		- - -
	4.	METERING	4000/ 2000/ 1000/1	20 20 20	0.2S 0.2S 0.2S	- - -		- - -
	5.	TRANS. BACK UP/LINE PROTN.	4000/ 2000/ 1000/1	-	PX	4000/ 2000/ 1000	15/10/5	20 on 4000/1 TAP; 30 on 2000/1; 60 on 1000/1 tap
	6.	TRANS. DIFF. /LINE PROTN.	4000/ 2000/ 1000/1	-	PX	4000/ 2000/ 1000	15/10/5	20 on 4000/1 TAP; 30 on 2000/1; 60 on 1000/1 tap

Note: 1. Protection cores shall be of accuracy class PX as per IEC 61869.
2. Metering Core shall be of accuracy class 0.2S as per IEC: 61869

TABLE-3B**REQUIREMENTS FOR 400 kV CURRENT TRANSFORMER**

No. of cores	Core No.	Application	Ratio	Output Burden	Accuracy Class	Min. Knee Pt. Voltage (Vk)	Max. CT Sec. wdg. Resistance (in Ω)	Max. Excit. Current at Vk (in mA)
6	1	BUS DIFF. CHECK	2000/ 1000/ 500/1	-	PX	2000/ 1000/ 500	10/5/2.5	30 on 2000/1 TAP; 60 on 1000/1; 120 on 500/1 tap
	2.	BUS DIFF. MAIN	4000/ 2000/ 500/1	-	PX	2000/ 1000/ 500	10/5/2.5	30 on 2000/1 TAP; 60 on 1000/1; 120 on 500/1 tap
	3.	METERING	4000/ 2000/ 500/1	20 20 20	0.2S 0.2S 0.2S	- - -		- - -
	4.	METERING	4000/ 2000/ 500/1	20 20 20	0.2S 0.2S 0.2S	- - -		- - -
	5.	TRANS. BACK UP/LINE PROTN.	4000/ 2000/ 500/1	-	PX	2000/ 1000/ 500	10/5/2.5	30 on 2000/1 TAP; 60 on 1000/1; 120 on 500/1 tap
	6.	TRANS. DIFF. /LINE PROTN.	4000/ 2000/ 500/1	-	PX	2000/ 1000/ 500	10/5/2.5	30 on 2000/1 TAP; 60 on 1000/1; 120 on 500/1 tap

Note: 1. Protection cores shall be of accuracy class PX as per IEC 61869.

2. Metering Core shall be of accuracy class 0.2S as per IEC: 61869

TABLE-3C
REQUIREMENTS FOR 245 KV CURRENT TRANSFORMER

No.of Cores	Core No.	Appli-cation	Current ratio	Output burden (VA)	Accuracy class	Min. knee pt.voltage (Vk)	Max. CT sec.wdg. resistance(ohms)	Max. Excitation current at Vk (in mA)
5	1	BUS DIFF CHECK	3000-2000/1	-	PX	3000/2000	15/10	10 on 3000/1 Tap; 30 on 2000/1 Tap
	2	BUS DIFF MAIN	3000-2000/1	-	PX	3000/2000	15/10	10 on 3000/1 Tap; 30 on 2000/1 Tap
	3	METERING	3000-2000/1	20	0.2S	-	-	-
	4	TRANS. BACK UP/LINE PROTN.	3000-2000/1	-	PX	3000/2000	15/10	10 on 3000/1 Tap; 30 on 2000/1 Tap
	5	TRANS. DIFF/LINE PROTN	3000-2000/1	-	PX	3000/2000	15/10	10 on 3000/1 Tap; 30 on 2000/1 Tap

Note: 1. Protection cores shall be of accuracy class PX as per IEC 61869.
2. Metering Core shall be of accuracy class 0.2S as per IEC: 61869

TABLE - 3D
REQUIREMENTS FOR 245 KV CURRENT TRANSFORMER

No.of Cores	Core No.	Appli-cation	Current ratio	Output burden (VA)	Accurac y class	Min. knee pt.volt-age (Vk)	Max. CT sec.wdg. resist-ance(ohms)	Max. Excit-ation cur-rent at Vk (in mA)
5	1	BUS DIFF CHECK	2000-1000/1	-	PX	2000/1000	10/5	30 on 2000/1 Tap; 60 on 1000/1 Tap
	2	BUS DIFF MAIN	2000-1000/1	-	PX	2000/1000	10/5	30 on 2000/1 Tap; 60 on 1000/1 Tap
	3	METERING	2000-1000/1	20	0.2S	-	-	-
	4	TRANS. BACK UP/LINE PROTN.	2000-1000/1	-	PX	2000/1000	10/5	30 on 2000/1 Tap; 60 on 1000/1 Tap
	5	TRANS. DIFF/LINE PROTN	2000-1000/1	-	PX	2000/1000	10/5	30 on 2000/1 Tap; 60 on 1000/1 Tap

Note: 1. Protection cores shall be of accuracy class PX as per IEC 61869.
2. Metering Core shall be of accuracy class 0.2S as per IEC: 61869

TABLE – 3E
REQUIREMENTS FOR 220 kV CURRENT TRANSFORMER

No.of Cores	Core No.	Appli- cation	Current ratio	Output burden (VA)	Accuracy class	Min. knee pt.volt- age (Vk)	Max. CT sec.wdg. resist- ance(ohms)	Max. Excit- ation cur- rent at Vk (in mA)
5	1	BUS DIFF	1600-8/4	-	PX 25 on CHECK	1600/800/1		800 1600/1 Tap; 50 on 800/1 Tap
	2	BUS DIFF	1600-8/4	-	PX 25 on MAIN 50 on	1600/800/1	Tap;	800 1600/1
	3	METERING	1600-800/1	20	0.2S	-	-	-
	4	TRANS. BACK UP/LINE PROTN.	1600-800/1	-	PX	1600/800	8/4	25 on 1600/1 Tap; 50 on 800/1 Tap
	5	TRANS. DIFF/LINE PROTN	1600-800/1	-	PX	1600/800	8/4	25 on 1600/1 Tap; 50 on 800/1 Tap

Note: 1. Protection cores shall be of accuracy class PX as per IEC 61869.
2. Metering Core shall be of accuracy class 0.2S as per IEC: 61869

TABLE - 3F

REQUIREMENTS FOR 145 KV CURRENT TRANSFORMER

No. of Cores	Core No.	Appli- cation	Current ratio	Output burden (VA)	Accurac y class	Min. knee pt.volt- age Vk	Max. CT sec.wdg. resist- ance(ohms)	Max. Excit- ation cur- rent at Vk (in mA)
5	1	BUS DIFF CHECK	2000-1000/1	-	PX	2000/1000	10/5	30 on 2000/1 Tap; 60 on 1000/1 Tap
	2	BUS DIFF MAIN	2000-1000/1	-	PX	2000 / 1000	10/5	30on 2000/1 Tap; 60 on 1000/1 Tap
	3	METERING	2000-1000/1	20	0.2S	-	-	-
	4	TRANS. BACK UP/LINE PROTN.	2000-1000/1	20	5P20	-	-	-
	5	TRANS. DIFF/LINE PROTN	2000-1000/1	-	PX	2000 / 1000	10/5	30 on 2000/1 Tap; 60 on 1000/1 Tap

Note: 1. Protection cores shall be of accuracy class PX as per IEC 61869.
2. Metering Core shall be of accuracy class 0.2S as per IEC: 61869

TABLE-3G**REQUIREMENTS FOR 145 KV CURRENT TRANSFORMER**

No.of Cores	Core No.	Appli- cation	Current ratio	Output burde n (VA)	Accuracy class	Min. knee pt.volt- age Vk	Max. CT sec.wdg. resist- ance(ohms)	Max. Excit- ation cur- rent at Vk (in mA)
5	1	BUS DIFF CHECK	1600- 800/1	-	PX	1600/ 800	16/8	25 on 800/1 Tap; 50 on 400/ 1 Tap
	2	BUS DIFF MAIN	1600- 800/1	-	PX	160 0/ 800	16/8	25 on 800/1 Tap; 50 on 400/1 Tap
	3	METERING	1600- 800/1	20	0.2S	-	-	-
	4	TRANS. BACK UP/LINE PROTN.	1600- 800/1	20	5P20	-	-	-
	5	TRANS. DIFF/LINE PROTN	1600- 800/1	-	PX	160 0/ 800	16/8	25 on 800/1 Tap; 50 on 400/ 1 Tap

Note: 1. Protection cores shall be of accuracy class PX as per IEC 61869.

2. Metering Core shall be of accuracy class 0.2S as per IEC: 61869

TABLE-3H**REQUIREMENTS FOR 145 kV CURRENT TRANSFORMER**

No.of Cores	Core No.	Appli-cation	Current ratio	Output burden (VA)	Accuracy class	Min. knee pt.voltage V _k	Max. CT sec.wdg. resist-ance(ohms)	Max. Excitation current at V _k (in mA)
5	1	BUS DIFF CHECK	800-400/1	-	PX	800/400	8/4	30 on 800/1 Tap; 60 on 400/1 Tap
	2	BUS DIFF MAIN	800-400/1	-	PX	800/400	8/4	30 on 800/1 Tap; on 400/1 Tap
	3	METERING	800-400/1	20	0.2S	-	-	-
	4	TRANS. BACK UP/LINE PROTN.	800-400/1	20	5P20	-	-	-
	5	TRANS. DIFF/LINE PROTN	800-400/1	-	PX	800/400	8/4	30 on 800/1 Tap; 60 on 400/1 Tap

Note: 1. Protection cores shall be of accuracy class PX as per IEC 61869.

2. Metering Core shall be of accuracy class 0.2S as per IEC: 61869

TABLE-3I**REQUIREMENTS FOR 66 KV CURRENT TRANSFORMER**

No.of Cores	Core No.	Appli-cation	Current ratio	Output burden (VA)	Accuracy class	Min. knee pt.voltage Vk	Max. CT sec.wdg. resistance(ohms)	Max.Excitation current at Vk (in mA)
5	1	BUS DIFF	2000-	-	PX	2000 /	10/5	30 on
		CHECK	1000/1			1000		2000/1 Tap; 60 on 1000/1 Tap
	2	BUS DIFF	2000-	-	PX	2000 /	10/5	30 on
		MAIN	1000/1			1000		2000/1 Tap; 60 on 1000/1 Tap
	3	METERING	2000-1000/1	20	0.2S	-	-	-
	4	TRANS. BACK UP/LINE PROTN.	2000-1000/1	20	5P20	-	-	-
	5	TRANS. DIFF/LINE PROTN	2000-1000/1	-	PX	2000 / 1000	10/5	30 on 2000/1 Tap; 60 on 1000/1 Tap

Note: 1. Protection cores shall be of accuracy class PX/5P20 as per IEC 61869.
2. Metering Core shall be of accuracy class 0.2S as per IEC: 61869

TABLE - 3J
REQUIREMENTS FOR 66 KV CURRENT TRANSFORMER

No.of Cores	Core No.	Appli-cation	Current ratio	Output burden (VA)	Accuracy class	Min. knee pt.voltage Vk	Max. CT sec.wdg. resistance(ohms)	Max.Excitation current at Vk (in mA)
5	1	BUS DIFF	800-	-	PX	800/	8/4	25 on

	CHECK	400/1			400		1200/1 Tap; 50 on 600/ 1 Tap
2	BUS DIFF MAIN	800- 400/1	-	PX	800/ 400	8/4	25 on 1200/1 Tap; 50 on 600/ 1 Tap
3	METERING	800- 400/1	20	0.2S	-	-	-
4	TRANS. BACK UP/LINE PROTN.	800- 400/1	20	5P20	-	-	-
5	TRANS. DIFF/LINE PROTN	800- 400/1	-	PX	800/ 400	8/4	25 on 1200/1 Tap; 50 on 600/ 1 Tap

Note: 1. Protection cores shall be of accuracy class PX/5P20 as per IEC 61869.

2. Metering Core shall be of accuracy class 0.2S as per IEC: 61869

ANNEXURE-4**TECHNICAL PARAMETERS FOR VOLTAGE TRANSFORMERS**

S. No.	Description	400kV system	220kV system	132/66 kV system
1	Type (CVT/IVT)	CVT/IVT	CVT/IVT	CVT/IVT
2	Rated voltage, U _m (kVrms)	420	245	145/72.5
3	Rated frequency (Hz)	50	50	50
4	No. of Poles	1	1	1
5	Design ambient temperature (°C)	50	50	50
6	System fault level (kA)	63k A for 1 sec	50kA for 1 sec	40kA for 1sec
6	Standard reference range of frequencies for which the accuracies are valid	96% to 102% for protection and 99% to 101% for measurement		
7	High frequency capacitance for entire carrier frequency range (for CVT only)	Within 80% to 150% of rated capacitance		
8	Equivalent series resistance over entire carrier frequency range (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 design ambient temperature	As per IEC		
11	Rated Insulation levels			
a)	Full wave impulse withstand voltage (1.2/50 microsecond)			
i)	between line terminals and ground (kVpeak)	±1425	±1050	±650/+ 325
b)	Switching impulse withstand voltage (250/2500 microsecond) (dry and wet)			
i)	between line terminals and ground (kVpeak)	± 1050	-NA-	-NA-
c)	One minute power frequency dry withstand voltage (dry and wet)			
i)	between line terminals and ground (kVrms)	630 (dry only)	460	275/140
d)	One minute power frequency withstand voltage between secondary terminals & earth			
i)	between LV (HF) terminal and earth terminal (kVrms)	10kVrms for exposed terminals and 4kVrms for terminals enclosed in a weather proof box		
ii)	For secondary winding	3kVrms		

S. No.	Description	400kV system	220kV system	132/66 kV system
11	Max. radio interference voltage for frequency between 0.5 MHz and 2 MHz at (microvolts)	1000 at 266kV rms	1000 at 156kV rms	500 at 92kV rms/NA
12	Minimum Corona extinction voltage (kVrms)	320	-NA-	-NA-
13	Partial Discharge	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 plus 20% spare terminals evenly distributed on all TBs.		
15	Rated Total Thermal Burden (VA)	50VA/winding		
17	System neutral earthing	Effectively Earthed		

For other parameters, refer respective Table for the applicable voltage class of IVTs.

TABLE -4A[illegible]

ANNEXURE-5
TECHNICAL PARAMETERS OF GIS SURGE ARRESTOR

Sl. No.	Description	Unit	420kV SA	245kV SA	145kV SA	72.5kV SA
1	Nominal System Operating voltage	kV, rms	400	220	132	66
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	336	216	120	60
6	Continuous operating voltage at 50 deg.C	kV	267	168	102	51
7	Nominal discharge current		20 kA of 8/20 microsecond wave	10 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	10 kA of 8/20 microsecond wave	10 kA of 8/20 microsecond wave	10 kA of 8/20 microsecond wave
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	12kJ/kV	7kJ/kV	7kJ/kV	7kJ/kV
10	Max. switching surge residual voltage	kVp	670(at 2kA) 650 (at 500A)	500 (at 1kA)	280 (at 1kA)	136 (at 1kA)
11	Max. residual voltage at					
i)	5kA	kVp	-	560	310	160
ii)	10 kA nominal discharge current	kVp	800	600	330	170
iii)	20 kA nominal discharge current	kVp	850	-	-	-
iv)	Steep fronted wave residual voltage at 20 kA	kVp	925	-	-	-
12	Arrester classification		Station High duty(SH)	Station Medium duty (SM)	Station Medium duty (SM)	Station Medium duty (SM)

Sl. No.	Description	Unit	420kV SA	245kV SA	145kV SA	72.5kV SA
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	50	40	40
15	Low current long duration test value	As per IEC				
16	Insulation Level					
a)	Full wave impulse withstand voltage (1.2/50 microsec.)					
i)	Arrester Housing	kVpeak	As per latest IEC:60099-4	As per latest IEC:60099- 4	As per latest IEC:60099-4	As per latest IEC:60099-4
b)	Switching impulse withstand voltage (250/2500 micro-second) dry and wet					
i)	Arrester Housing	kV peak	± 1050	-NA-	-NA-	-NA-
c)	One minute power frequency dry withstand voltage					
i)	Arrester Housing	kV rms	As per latest IEC:60099-4	As per latest IEC:60099- 4	As per latest IEC:60099-4	As per latest IEC:60099-4
18	Partial Discharge at 1.05 COV		≤ 10pC	≤ 10pC	≤ 10pC	≤ 10pC
19	System neutral earthing		Effectively Earthed	Effectively Earthed	Effectively Earthed	Effectively Earthed

ANNEXURE-6
TECHNICAL PARAMETERS FOR SF6/AIR BUSHING

Sl. No.	Particular	400 kV	220 kV	132kV	66kV
1	Rated Voltage (kV)	420 kV (rms)	245 kV (rms)	145 kV (rms)	72.5 kV (rms)
2	Rated Current (Amp)	As per BPS	As per BPS	As per BPS	As per BPS
3	1.2/50 micro second impulse voltage (Lightning impulse withstand voltage)	1425 kVp	1050 kVp	630 kVp	325 kVp
4	250/2500 micro second switching impulse voltage	1050 kVp	-		
5	One minute power frequency withstand voltage	650 kV (rms)	460 kV (rms)	275 kV (rms)	140 kV (rms)
6	Minimum total Creepage distance in mm	10500	6125	3625	1813
7	Minimum strength (kN) Cantilever	10	8	5	5