

SECTION -GIS

TECHNICAL SPECIFICATION FOR SF6 GAS INSULATED METAL ENCLOSED SWITCHGEAR (GIS)

1.0 GENERAL CHARACTERISTICS

The SF6 gas insulated metal enclosed switchgear shall be totally safe against inadvertent touch of any of its live constituent parts. It should be designed for indoor/outdoor (as specified) application with meteorological conditions at site as per Section Project. All parts of the switchgear should be single phase enclosed for 400 kV and single phase/three phase enclosed for 220 kV.

The arrangement of gas sections or compartments shall be such as to facilitate future extension of any make on either end without any drilling, cutting or welding on the existing equipment. To add an equipment, it shall not be necessary to move or dislocate the existing switchgear bays. As the 400/220kV GIS is likely to be extended in future on either side, the contractor shall make available during detailed engineering stage, all details such as cross section, gas pressure, extension conductor piece to extend existing bus bar and all required material etc. for design of adopter in future for extension of GIS. GIS must be complete in all respects for future extension and there should be no requirement of any component/material of GIS from the present supplier at the time of future extension by another GIS manufacturer. The design should be such that all parts subjected to wear and tear are easily accessible for maintenance purposes. The equipment offered shall be protected against all types of voltage surges and any equipment necessary to satisfy this requirement shall be deemed to be included. The required overall parameters of GIS are as follows :-

Sl. No.	Technical particulars	400 kV System	220 kV System
a	Rated Voltage	420 kV (rms)	245 kV (rms)
b	Rated frequency	50 HZ	50 HZ
c	Grounding	Effectively earthed	Effectively earthed
d	Rated power frequency withstand Voltage (1min) line to earth	650 kV (rms)	460 kV (rms)
e	Impulse withstand BIL (1.2/50/mic. Sec) Line to earth	± 1425 kVp	± 1050 kVp

f	Switching impulse voltage (250/2500 mic.-sec)	1050 kVp	-
g	Rated short time withstand current (1 sec)	63/50/ 40 kA (rms) (As applicable)	50/ 40 kA (rms) (As applicable)
h	Rated peak withstand current	157.5/125/100 kA (peak) (as applicable)	125/100 kA (peak) (as applicable)
i	Guaranteed maximum gas losses for complete installation as well as for all individual sections in %	As per IEC- 62271-203	As per IEC- 62271-203
j	Rated current normal/ at site (at 50 degree C design ambient temperature)	As per schedule of requirement	As per schedule of requirement
k	Seismic level	Zone – II as per IS-1893, Year-2002	Zone – II as per IS-1893, Year-2002

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 IEC-62271-203 publications including their parts and supplements as amended or revised to date.

2.0 REFERENCE STANDARDS

The metal-enclosed gas-insulated switchgear, including the operating devices, accessories and auxiliary equipment forming integral part thereof, shall be designed, manufactured, assembled and tested in accordance with the following International Electro-technical Commission (IEC)

Publications including their parts and supplements as amended or revised to date:

IEC 62271-203 Gas Insulated metal-enclosed switchgear for rated voltages above 52KV

IEC 60376 New sulphur hexafluoride

IEC 62271- 100 High voltage alternating current Circuit breakers

IEC 62271-1 High voltage Switchgear and control-gear standards – common specifications

IEC 62271-102 Alternating current disconnectors(isolate) and earthing switches

IEC 61128 Alternating current disconnectors. Bus-transfer current

switching by
disconnectors.

IEC 61129 Alternating current earthing switches. Induced current switching

IEC 61869-2/1 Current transformers

IEC 61869-3/1 Voltage transformers

IEC 60137 Bushings for alternating voltages above 1000 V

IEC 62271-209 Cable connections for gas-insulated metal enclosed switchgear for rated voltage above 52kV

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.

IEC 62271-101 High-voltage Switchgear & control gear – synthetic test.

IEEE 80 (2000) IEEE Guide for Safety in AC Substation grounding.

CIGRE-44 Earthing of GIS- an application guide. (Electra no.151,Dec'93).

IEC 61639 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 latest applicable standards, rules, codes and regulations of the internationally recognized standardizing bodies and professional societies as may be approved by the Employer. The manufacturer shall list all applicable standards, codes etc. and provide copies thereof for necessary approval.

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

3.0 DEFINITIONS

3.1 Assembly

Assembly refers to the entire completed GIS equipment furnished under contract.

3.2 Bay

Bay refers to the area occupied by one Circuit Breaker and associated equipments used to protect one line/transformer/Reactor/bus coupler in double bus scheme/one and half breaker scheme and which comprises of atleast one circuit breaker, two disconnectors & 3 Nos. of single phase CT's/bushing CT's.

3.3 Compartment

When used in conjunction with GIS equipment, compartment refers to a gas tight volume bounded by enclosure walls and gas tight isolating barriers.

3.4 Enclosure

When used in conjunction with GIS equipment, enclosure refers to the grounded metal housing or shell which contains and protects internal Power system equipment (breaker, disconnecting switch, grounding switch, voltage transformer, current transformer surge arresters, interconnecting bus etc.)

3.5 Manual Operations

Manual operation means operation by hand without using any other source of Power.

3.6 Module

When used in conjunction with GIS equipment, module refers to a portion of that equipment. Each module includes its own enclosure. A module can contain more than one piece of equipment, for example, a module can contain a disconnecting switch and a grounding switch.

3.7 Reservoir

When used in conjunction with GIS equipment reservoir refers to a larger gastight volume.

4.0 GENERAL DESIGN AND SAFETY REQUIREMENT

- 4.1. 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.

- 4.2. The workmanship shall be of the highest quality and shall conform to the latest modern practices for the manufacture of high technology machinery and electrical switchgear.
- 4.3. 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 atleast 5 % greater than the rated voltage .They should 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.
- 4.4. Gas barrier insulators and support insulators shall have the same basis of design. The support insulators shall have holes on both sides for proper flow of gas.
- 4.5. Gas barrier insulators shall be provided so as to divide the GIS into separate compartments. They shall be suitably located in order to minimize disturbance in case of leakage or dismantling. They shall be designed to withstand any internal fault thereby keeping an internal arc inside the faulty compartment. Due to safety requirement for working on this pressurized equipment, whenever the pressure of the adjacent gas compartment is reduced, it should be ensured by the bidder that adjacent compartment would remain in service and also isolate/earth the gas compartments which is not at minimum operating pressure. The gas tight barriers shall be clearly marked on the outside of the enclosures. The service continuity of GIS shall confirm to Annexure-F of IEC :62271-203.
- 4.6. The material and thickness of the enclosures shall be such as to

withstand an internal flash over without burn through for a period as specified in IEC at rated short time withstand current. The material shall be such that it has no effect of environment as well as from the by-products of SF6 breakdown under arcing condition.

- 4.7. Each section shall have plug- in or easily removable connection pieces to allow for easy replacement of any component with the minimum of disturbance to the remainder of the equipment. Inspection windows shall be provided for disconnect and earth switches.
- 4.8. The material used for manufacturing the switchgear equipment shall be of the type, composition and have physical properties best suited to their particular purposes and in accordance with the latest engineering practices. All the conductors shall be fabricated of aluminum/ copper tubes of cross sectional area suitable to meet the normal and short circuit current rating requirements. The finish of the conductors shall be smooth so as to prevent any electrical discharge. The conductor ends shall be silver plated and fitted into finger contacts or tulip contacts. The contacts shall be of sliding type to allow the conductors to expand or contract axially due to temperature variation without imposing any mechanical stress on supporting insulators.
- 4.9. Each pressure filled enclosure shall be designed and fabricated to comply with the requirements of the applicable pressure vessel codes and based on the design temperature and design pressures as defined in IEC-62271-203.
- 4.10. The manufacturer shall guarantee that the pressure loss within each individual gas-filled compartment shall not be more than half percent (0.5%) per year.
- 4.11. Each gas-filled compartment shall be equipped with static filters, density switches, filling valve and safety diaphragm. The filters shall be capable of absorbing any water vapour which may penetrate into the enclosures as well as the by-products of SF6 during interruption. Each gas compartment shall be fitted with separate non-return valve connectors for evacuating & filling the gas and checking the gas pressure etc.
- 4.12. The switchgear line-up when installed and operating under the

ambient conditions shall perform satisfactorily and safely under all normal and fault conditions. Even repeated operations up to the permissible servicing intervals under 100% rated and fault conditions shall not diminish the performance or significantly shorten the useful life of the switchgear. Any fault caused by external reasons shall be positively confined to the originating compartment and shall not spread to other parts of the switchgear.

4.13. The thermal rating of all current carrying parts shall be minimum for one sec. for the rated symmetrical short-circuit current.

4.14. The switchgear shall be of the free standing, self-supporting with easy accessibility to all the parts during installation & maintenance with all high-voltage equipment installed inside gas-insulated metallic and earthed enclosures, suitably subdivided into individual arc and gas-proof compartments preferably for:

- a) Bus bars
- b) Intermediate compartment
- c) Circuit breakers
- d) Line disconnectors
- e) Voltage Transformers
- f) Gas Insulated bus duct section between GIS and XLPE cable/Overhead Conductor.
- g) Gas Insulated bus section between GIS & Oil filled Transformer/ Reactor

The bus enclosure should be sectionalized in a manner that maintenance work on any bus disconnector (when bus and bus disconnector are enclosed in a single enclosure) can be carried out by isolating and evacuating the small effected section and not the entire bus. The design of GIS shall be such that in case a circuit breaker module of a feeder is removed for maintenance, both busbars shall remain in service. For achieving the above requirements, adequate number of intermediate compartments, if required, shall be provided to ensure equipment and operating personnel's safety. The service continuity of GIS shall confirm to Annexure-F of IEC :62271-203.

4.15. The arrangement of the individual switchgear bays shall be such so as to achieve optimum space-saving, neat and logical

arrangement and adequate accessibility to all external components.

- 4.16. The layout of the substation equipment ,busbars 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 owner. The arrangement of the equipment offered must provide adequate access for operation, testing and maintenance.

4.17. LOCAL CONTROL CUBICLE (LCC)

14.17.1. Functions

- 14.17.1.1 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.
- 14.17.1.2. Status indications in the LCC shall be semaphore type or LED type.
- 14.17.1.3. 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 Technical Specification Gas Insulated Switchgear Page 37 of 80 Rev 05 (April 2018) maintenance and emergency conditions only. The emergency trip push buttons shall be properly shrouded.
- 14.17.1.4. If Disconnecter or earth switch is not in the fully open or closed position a "Control Circuit Faulty" alarm shall be initiated, and electrical operation shall be blocked.
- 14.17.1.5. 20% spare terminals shall be provided in each LCC apart from terminals provided for the termination and interconnection of all cabling associated with remote and supervisory control, alarms, indications, protection and main power supply etc .
- 14.17.1.6.. 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.
- 14.17.1.7. Hydraulic/pneumatic and SF6 auxiliary equipment necessary for the correct functioning of the circuit breaker, isolators and earth switches shall be located in a separate cubicle compartment.

14.17.1.8. LCC shall be suitable for remote operation from substation automation system (SAS). Each gas tight compartment shall be monitored individually per phase basis through SAS

14.17.2. Constructional features

14.17.2.1. 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.

14.17.2.2. 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. However, XLPE gaskets can also be used for fixing protective glass doors.

14.17.2.3. 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.

14.17.2.4. Each panel shall be provided with necessary arrangements for receiving, distributing and isolating of DC and AC supplies for various control, signaling, lighting and space heater circuits. The incoming and sub-circuits shall be separately provided with Fuses/MCBs. All fuses shall be HRC cartridge type conforming to IS: 13703 mounted on plug-in type fuse Technical Specification Gas Insulated Switchgear Page 38 of 80

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bases. The short time fuse rating of Fuses shall be not less than 9 KA. Fuse carrier base shall have imprints of the fuse 'rating' and 'voltage'.

14.17.2.5. Each LCC Panel shall be provided with the following

1. **Plug Point:** 240V, Single phase 50Hz, AC socket with switch suitable to accept 5/15 Amps pin round standard Indian plug, shall be provided in the interior of each cubicle with ON-OFF switch.

2. **Interior Lighting:** Each panel shall be provided with a door-operated LED lighting fixture rated for 240 Volts, single phase, 50 Hz supply for the interior illumination of the panel controlled by the respective panel door switch.

3. **Space Heater:** Each panel shall be provided with a thermostatically connected space heater rated for 240V, single phase, 50 Hz AC supply for the internal heating of the panel to prevent condensation of moisture. The fittings shall be complete with switch unit.
- 14.17.2.6. 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.
- 14.17.2.7. 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.
- 14.17.2.8. 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.
- 14.17.2.9. 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.
- 14.17.2.10. 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.
- 14.17.2.11. 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 Technical Specification Gas Insulated Switchgear Page 39 of 80 Rev 05 (April 2018) possible by interlocks which ensure that the associated bus coupler and its isolators are closed.
- 14.17.2.12. 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.-
- 14.17.2.13. 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.

14.17.3. Cabling between LCC Panel and GIS equipment

14.17.3.1. The unarmored screen cable shall be of 1.1kV grade, multi core, annealed copper conductor, Tinned copper braided screen (approx. 85% coverage).

14.17.3.2. The core insulation and outer sheath of cable shall be of halogen-free special polymer.

14.17.3.3. The cable shall be flame-retardant, flexible, abrasion-and wear-resistant.

14.17.3.4. 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.

14.17.3.5. Prefabricated cables with heavy duty multi-point plug-in connections on GIS end shall be provided.

14.17.3.6. All instrument transformer connections shall be hard wired to terminal block via ring type connection.

The LCC panel as a separate item may be considered if the bidder desires to supply from the manufacturer other than GIS supplier. The make of LCC panel shall be KPTCL approved C&R panel vendors make only. Also, the interfacing of LCC panel with original GIS module in respect of schemes, TB nos, Ferrule nos etc., is in the scope of Bidder

The supply of power and control cables and cabling from GIS module up to Local Control Panels shall be in GIS module supplier/BIDDER's scope.

4.18. All the elements shall be accessible without removing support structures for routine inspections and possible repairs. The removal of individual enclosure parts, or entire breaker bays shall be possible without disturbing the enclosures of neighboring bays.

4.19. It should be impossible to unwillingly touch live parts of the switchgear or to perform operations that lead to arcing faults without the use of tools or brute force.

4.20. In case of any repair or maintenance on one busbar disconnectors, the other busbar should be live and in service.

4.21. All interlocks that prevent potentially dangerous mal-operations, shall be constructed such that they can not be operated easily, i.e. the operator must use tools or brute force to over-ride them.

4.22. In general the contours of energized metal parts of the GIS and any other accessory shall be such, so as to eliminate areas or

points of high electrostatic flux concentrations. The surfaces shall be smooth with no projection or irregularities which may cause visible corona. No corona shall be visible in complete darkness which the equipment is subjected to specified test voltage. There shall be no radio interference from the energized switchgear at rated voltage.

- 4.23. The enclosure shall be of continuous design and shall meet the requirement as specified in clause no. 10 (special considerations for GIS) of IEEE- 80, Year- 2000 . The enclosure shall be sized for carrying induced current equal to the rated current of the Bus. The conductor and the enclosure shall form the concentric pair with effective shielding of the field internal to the enclosure.
- 4.24. The fabricated metal enclosures 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 conform to metric system.
- 4.25. The breaker enclosure shall have provision for easy withdrawal of the interrupter assemblies. The removed interrupter assembly must be easily and safely accessible for inspection and possible repairs.
- 4.26. The enclosure shall be designed to practically eliminate the external electromagnetic field and thereby electrodynamic stresses even under short circuit conditions.
- 4.27. The elbows, bends, cross and T-sections of interconnections shall include the insulators bearing the conductor when the direction changes take place in order to ensure that live parts remain perfectly centered and the electrical field is not increased at such points.
- 4.28. The Average Intensity of electromagnetic field shall not be more than 50 micro –Tesla on the surface of the enclosure. The contractor shall furnish all calculations and documents in support of the above during detailed engineering.
- 4.29. The Bidder shall furnish the following information regarding the loosely distributed metallic particles within the GIS encapsulation.

- a) Calculations of critical field strength for specific particles of defined mass and geometry.
 - b) The methodology and all the equipment for electrical partial discharge (PD) detection including that mentioned in the specification else-where.
- 4.30. The switchgear shall have provision for connection with ground mat risers. This provision shall consist of grounding pads to be connected to the ground mat riser in the vicinity of the equipment.
- 4.31. The ladders and walkways shall be provided wherever necessary for access to the equipment. A portable ladder with adjustable height may also be supplied to access to the equipment.
- 4.32. Wherever required, the heaters shall be provided for the equipment in order to ensure the proper functioning of the switchgear at specified ambient temperatures. The heaters shall be rated for 240V AC supply and shall be complete with thermostat, control switches and fuses, connected as a balanced 3-phsase. 4-wire load. The possibility of using heaters without thermostats in order to achieve the higher reliability may be examined by the bidder and accordingly included in the offer but it shall be ensured by the bidder that the temperature rise of different enclosures where heating is provided should be within safe limits as per relevant standards. One copy of the relevant extract of standard to which the above arrangement conforms along with cost reduction in offer. If any, shall also be furnished along with the offer. The heaters shall be so arranged and protected as to create no hazard to adjacent equipment from the heat produced.
- 4.33. The enclosure & support structure shall be designed that a mechanic 1780 mm in height and 80 Kg in weight is able to climb on the equipment for maintenance.
- 4.34. The sealing provided between flanges of two modules / enclosures shall be such that long term tightness is achieved.
- 4.35. 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.

- 4.35.1. Gas Insulating System:
- a) Loss of Gas Density.
 - b) Loss of Heater power(if required)
 - c) Any other alarm necessary to indicate deterioration of the gas insulating system.

- 4.35.2. Operating System:
- a) Low operating pressure.
 - b) Loss of Heater power.
 - c) Loss of operating power.
 - d) Loss of control.
 - e) Pole Disordance.

4.36. The equipment will be operated under the following ambient conditions:

- 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 metres.

4.37. Temperature rise of current carrying parts shall be limited to the values stipulated in IEC-62271-1, under rated current and the climatic conditions at site. The temperature rise for accessible enclosure shall not exceed 20 degree C above the ambient temperature of 50 degree C. In the case of enclosures, which are accessible but need not be touched during normal operation, the temperature rise limit may be permitted upto 30 degree C above the ambient of 50° C.

These conditions shall be taken into account by the supplier in the design of the equipment.

5.

5.1 Type tests: The offered 400/220kV GIS equipments shall conform to the type tests as per IEC-62271-203.

The type tests certificates should not be older than FIFTEEN(15) years as on the last date of submission of bid.

a) For Equipments manufactured in India:

- i). The type tests on indigenous equipment for which testing facility is available in India, should have been conducted in any independent laboratories approved by the Government or the laboratories accredited

by the National accreditation body of the country like Central Power Research Institute (CPRI), Electrical Research and Development Association (ERDA), etc.

- ii). The type tests on indigenous equipment, for which testing facility is not available in India, should have been conducted in a laboratory of foreign country accredited by National accreditation body of that country.
- iii). The type tests conducted in-house by a manufacturer shall also be acceptable provided the laboratory is accredited by National accreditation body of the country and the tests has been conducted in the presence of a representative of NABL accredited laboratory or any of the purchasing utilities or CEA in that order. Such type test reports shall record the details of such witness including the signature/authentication in the type test report.

b) For Equipments manufactured Abroad:

- i). Type tests on imported equipment should have been conducted in an Indian Laboratory or foreign laboratory accredited by National accreditation body of the country where the Type test has been conducted.
- ii). The type tests conducted in-house by a manufacturer shall also be acceptable provided the laboratory is accredited by National accreditation body of the country and the tests has been conducted in the presence of a representative of accredited laboratory or any of the purchasing utilities or CEA in that order. Such type test reports shall record the details of such witness including the signature/authentication in the type test report.

In case of in-house type tested imported equipment of foreign OEM, the term “Purchasing Utility” covers the foreign Utility who has purchased that equipment.

Contractor shall submit type test reports for the following type tests & additional type tests.

Sl. No.	Description of the Type Test for 400kV and 220kV 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	Tests to prove the radio interference voltage (RIV) level (if applicable)
15	Electromagnetic Compatibility Test (EMC)
16	Reactor current switching test.
17	Test to demonstrate the Power frequency withstand capability of breaker in open condition at lock out pressure [ref clause No. 11.4(vi)]

The test reports of the above type tests for GIS as well as all type tests on 400kV SF6/ Air bushing as per IEC 60137 shall be submitted for approval as per section-GTR of Technical specification.

5.2: Routine Tests:

- a) Routine tests shall be made either in the course of component assembly and / or on the complete shipping unit assembly.

The following routine tests shall be performed as per IEC 62271-203 at the factory on every unit following its manufacture:

- i. Dielectric test on the main circuit.
- ii. Tests on auxiliary and control circuits
- iii. Measurement of the resistance of the main circuit.
- iv. Tightness test.
- v. Design and visual checks.
- vi. Pressure tests of enclosures.
- i. Mechanical operation tests.
- ii. Tests on auxiliary circuits, equipment and interlocks in the control mechanism.
- iii. Pressure test on partitions.

Note: Tests on transport units.

GIS modules or components shall be assembled in the factory to transport units. The size of the transport units shall be defined by engineering and shall be as large as practical for shipment to the site and handling during

installation. On assembly units without support or barrier insulator dielectric tests are not necessary.

5.3 KPTCL may insist for conducting all or some of the routine tests at the factory premises during inspection of the GIS module by KPTCL Engineers.

5.4 Tests after installation on site:

After the switchgear has been completely installed on site & filled with SF6 gas, the complete assembly shall be subjected to the following site test as per IEC: 62271-203.

- a) Dielectric tests on the main circuit.
- b) Dielectric tests on auxiliary circuit.
- c) Measurement of the resistance of the main circuit.
- d) Gas tightness tests.
- e) Checks and verifications.
- f) Gas quality verifications.
- g) ON SITE HV TESTINGS.

6. Bellows or Compensating Units :-

Adequate provision shall be made to allow for the thermal expansion of the conductors and of differential thermal expansion between the conductors and the enclosures. The bellows shall be metallic (preferably of stainless steel) of following types or other suitable equivalent arrangement shall be provided wherever necessary.

- 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.

6. The electrical connections across the bellows or compensating units shall be made by means of suitable connectors.

7. 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. Windows shall also be provided with all isolators and earthswitches so that the switch contact positions can be verified by direct visual inspection.

8. PRESSURE RELIEF:-

Pressure relief devices shall be provided in the gas sections to protect the main gas enclosures from damage or distortion during the occurrence of abnormal pressure increase or shock waves generated by internal electrical fault arcs (preferably in downward direction). Pressure relief shall be achieved either by means of diaphragms or plugs venting directly into the atmosphere in a controlled direction. If the pressure relief devices vent directly into the atmosphere, suitable guards and deflectors shall be provided. Contractor shall submit to the owner the detailed criteria/ design regarding location of pressure relief devices/rupture diaphragms.

9. 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.) Each enclosure has to be tested as a routine test at 1.5 time the design pressure for one minute. The bursting strength of Aluminium 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.

10. EARTHING:

- 10.1 The MANUFACTURER shall provide a “Main Ground Bus Earth mat”, rated 63kA/50kA for 3 sec (as required)., to which all intentionally earthed parts of the assembly must be connected.

- 10.2 It shall be the responsibility of the VENDOR to provide a sufficient number of earth points so that dangerous voltages are not induced in the enclosure by the fault currents circulating in the inner conductor.
- 10.3 Earthing pads shall be provided for at-least two paths to earth from the “Main Earth Bus” or each metallic enclosure and auxiliary equipment designated for connection to the station earth grid. The VENDOR shall provide data to assure that the connections from the “Main Earth Bus” to the station earth will not interfere with required enclosure current paths or any operational feature of the assembly. A copper earth bar, located near the control cable entrances of all main and auxiliary equipment, shall be provided for the purpose of terminating the shield of each control cable.
- 10.4 Provision shall be made for future extension and/or connection to earth buses of other interconnecting switchgear.
- 10.5 The BIDDER shall be responsible for supplying all earthing materials required for bonding all the equipment and steel work included in this contract to the main station earth mat also to be provided by the BIDDER.
- 10.6 The design of the earth system and connection to the switchgear equipment shall also be compatible with the circulating currents that are present in the switchgear metal cladding. On the design of the earth mat mesh, the VENDOR shall provide full details of the circulating currents expected to flow in the earth mat system.
- 10.7 Every section of the SF6 switchgear equipment including all panels, cubicles, kiosks and boxes shall be solidly bonded to the earthing system.
- 10.8 Earth switches, voltage transformers, panels and kiosks, shall be bonded to the earthing system as specified in the relevant previous clauses.
- 10.9 All steelwork, access decking and gangways, handrails, etc., shall also be effectively bonded to the earthing system.
- 10.10 The design of the earthing system along with the station earth mat shall be such as to ensure the safety and protection of all

operating and maintenance personnel under all normal and fault conditions. Detailed earthing drawings shall be prepared for the complete installation which shall be provided under this contract and submitted to the PURCHASER for approval.

10.11 The enclosure of the equipment and support structure of GIS shall be earthed in such a way that the following conditions are obtained:

- a) The touch potential at any part of the enclosure is less than 65 V.
- b) The induced current during normal operation is prevented from entering the earthing grid.

10.12 GIS Module earth mat has to be provided by the bidder for which detailed calculation and drawings to be furnished.

10.13 GROUNDING

The grounding system shall be designed and provided as per IEEE-80-2000 and CIGRE-44 to protect operating staff against any hazardous touch voltages and electro-magnetic interferences. The GIS supplier shall define clearly what constitutes the main grounding bus of the GIS. The GIS supplier must supply the entire material for grounding bus of GIS viz conductor, clamps, joints, operating and safety platforms etc. The GIS supplier is also required to supply all the earthing conductors and associated hardware material for the following:

- 1) Connecting all GIS equipment, bus ducts, enclosures, control cabinets, supporting structure etc. to the ground bus of GIS.
- 2).

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, transformer terminals, cable terminals, surge arrestors, earth switches and at each end of the bus bars. The grounding continuity between each enclosure shall be effectively interconnected with Cu/ Al bonds of suitable size to bridge the flanges. In case the bidder does not offer external bonding, the bidder shall demonstrate that the connectivity offered by them between each enclosure is effective and does not require external bonding. Further similar design should have been in service. Subassembly to subassembly bonding shall be provided to provide gap & safe voltage gradients between all intentionally grounded parts of the GIS assembly &

between those parts and the main grounding bus of the GIS.

Each marshalling box, local control panel, power and control cable sheaths and other non current carrying metallic structures shall be connected to the grounding system of GIS via connections that are separated from GIS enclosures. 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.

All flexible bonding leads shall be tinned copper. All connectors, for attaching flexible bonding leads to grounding conductors and grounding conductors to support structures shall be tinned bronze with stainless steel or tinned bronze hardware.

The contractor shall provide suitable measure to mitigate transient enclosure voltage caused by high frequency currents caused by lightning strikes, operation of surge arrestor, ph./ earth fault and discharges between contacts during switching operation. The grounding system shall ensure safe touch & step voltages in all the enclosures. The contractor shall provide suitable barrier of non-linear resistor/ counter discontinued SF6/ Air termination, SF6/ Transformer or Reactor termination, SF6/ HV cable bushing etc. to mitigate transient enclosure voltage.

11. CIRCUIT BREAKERS

11.1 General

SF6 gas insulated metal enclosed circuit breakers shall comply with the latest revisions of IEC- 62271-100 & relevant IEC except to the extent explicitly modified in the specification and shall meet with requirements specified.

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

11.2. 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 400/220 kV effectively grounded system, with transmission lines of lengths and characteristics as indicated in Section Project and perform make and break operations as per the stipulated duty cycles satisfactorily.

11.3 PRE INSERTION RESISTER

400 kV circuit breakers for line bay 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. The value of the pre-insertion resistor and the duration of pre-insertion time shall be as given in clause 10.7.3 of this chapter. The resistor shall have thermal rating for the following duties :

i) TERMINAL FAULT

Close 1 Min Open Close open 2 min close 1 Min open close open.

ii) RECLOSING AGAINST TRAPPED CHARGES

Duty same as under (i) 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. (Based on 1 pu = 653kV) of opposite polarity.

iii) OUT OF PHASE CLOSING

One closing operation under phase opposition that is with twice the voltage across the terminals.

iv) 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 alongwith the bid. The calculations shall take care of adverse tolerances on resistance values and time settings.

11.4. The circuit breaker shall be capable of:

- i) Interrupting the steady and transient magnetizing current corresponding to 400 kV/220 kV class transformers of 500MVA ratings on both 400 kV & 220 kV side.
- ii) Interrupting line/cable charging current as per IEC without

re-strikes and without use of opening resistors.

- iii) Clearing short line fault (Kilometric faults) with source impedance behind the bus equivalent to symmetrical fault current specified.
- iv) Breaking 25% the rated fault current at twice the rated voltage under phase opposition condition.
- v) The breaker shall satisfactorily withstand the high stresses imposed on them during fault clearing, load rejection and re-energisation of lines with trapped charges.
- vi) Withstanding all dielectric stresses imposed on it in open condition at lock out pressure continuously (ie., 2 p.u. across the breaker continuously, for validation of which a power frequency dielectric withstand test conducted for a duration of at least 15 minutes is acceptable).
- vii) 400 kV breakers shall be able to switch in and out the 400 kV shunt reactor for any value from 50 MVAR up to 80 MVAR without giving rise to overvoltage more than 2.3 p.u. Laboratory test and or field test reports in support of the same shall be furnished along with the bid.

11.5 Controlled Switching Requirements:

The circuit Breaker shall be equipped with controlled switching with consequent optimization of switching behavior when used in switching of 400kV Bus reactor & switchable Line reactor. The controller shall be provided in Main & Tie circuit breakers of Bus reactors.

The controlling relay 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.

11.5.1 Technical Requirement for controlled switching device:

1. The controller shall be designed to operate at the correctly and satisfactorily with the excursion of auxiliary A/C & DC voltages and frequency as specified in section – GTR.
2. The controller shall meet the requirements of IEC-60255-4 Appendix 'E' class III regarding HF disturbance test and fast transient test shall be as per IEC-61000-4 level III and insulation test as per 60255-5.
3. The controller shall have functions for switching ON & OFF the circuit breakers.
4. The controller shall get command to operate the breakers

manually or through auto reclose 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.

5. The controller shall also 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 next 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, hydraulic/pneumatic pressure of the operating mechanism, 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 + 0.5ms.
6. The controller should have display facility at the front for the settings and measured values.
7. The controller should be PC compatible for the setting of various parameters and down loading of the settings and measured values date time of witching etc. Window based software for this purpose shall be supplied by the contractor to be used on the owner's PC.
8. The controller shall have self-monitoring facility.
9. The controller shall be suitable for current input of 1 amp from the secondary of the CTs and 110V (ph to ph) from the CVTs. The controller shall also take care of transient and dynamic state values of the current from the secondary of the CTs and CVTs.
10. The controller shall have time setting resolution of 0.1ms or better
11. The controller 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.

11.6 Total Break Time

The total break time shall not be exceeded under any of the following duties :

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

- ii) Short line fault L90, L75 (with TRV as per IEC-62271-100)
- iii) The Bidder 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 bidder 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.

11.7. CONSTRUCTIONAL FEATURES

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

11.7.1. Contacts

All making and breaking contacts' shall be sealed and free from atmospheric effects. Contacts shall be designed to have adequate thermal and current carrying capacity for the duty specified and to have a life expectancy so that frequent replacement due to excessive burning will not be necessary. Provision shall be made for rapid dissipation of heat generated by the arc on opening.

11.7.2. Any device provided for voltage grading to damp oscillations or, to prevent re-strike prior to the complete interruption of the circuit or to limit over voltage on closing, shall have a life expectancy comparable of that of the breaker as a whole.

11.7.3. Breakers shall be so designed that when operated within their specified rating, the temperature of each part will be limited to values consistent with a long life for the material used. The temperature rise shall not exceed that indicated in IEC-62271-100 under specified ambient conditions.

11.7.4. The gap between the open contacts shall be such that it can withstand atleast the rated phase to ground voltage for eight hours at zero pressure above atmospheric level of SF6 gas due to its leakage. The breaker should be able to withstand all dielectric stresses imposed on it in open condition at lockout pressure continuously (i.e. 2 pu. power frequency voltage across the breaker continuously)

11.7.5. In the interrupter assembly there shall be an adsorbing product box to minimize the effect of SF6 decomposition products and moisture. The material used in the construction of the circuit breakers shall be such as to be fully compatible with SF6 gas decomposition products.

11.7.6. Provisions shall be made for attaching an operational analyzer to record travel, speed and making measurement of operating timings etc. after installation at site.

11.8. OPERATING MECHANISM

11.8.1. General Requirements :

- a) Circuit breaker shall be operated by spring charged mechanism or electro hydraulic mechanism or a combination of these. The mechanism shall be housed in a dust proof cabinet and shall have IP : 42 degree of protection.
- b) The operating mechanism shall be strong, rigid, not subject to rebound or to critical adjustments at site and shall be readily accessible for maintenance.
- c) The operating mechanism shall be suitable for high speed reclosing and other duties specified. During reclosing the breaker contacts shall close fully and then open. The mechanism shall be antipumping and trip free (as per IEC definition) under every method of closing.
- d) The mechanism shall be such that the failure of any auxiliary spring will not prevent tripping and will not cause trip or closing operation of the power operating devices.
- e) A mechanical indicator shall be provided to show open and close position of the breaker. It shall be located in a position where it will be visible to a man standing on the ground level with the mechanism housing closed. An operation counter shall also be provided in the central control cabinet/operating Mechanism.
- 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 bidder shall furnish detailed operation and maintenance manual of the mechanism alongwith the operation manual for

the circuit breaker.

11.8.2. 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, valves, pressure switches, and coils each 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 central 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. If additional elements are introduced in the trip coil circuit their successful operation and reliability for similar applications on circuit breakers shall be clearly brought out in the additional information schedules. In the absence of adequate details the offer is likely to be rejected.
- f) Densimeter contacts and pressure switch contacts shall be suitable for direct use as permissives 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 for all auxiliary circuit shall be monitored and 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.

11.8.3. Spring operated Mechanism

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

- b) As long as power is available to the motor, a continuous sequence of the closing and opening operations shall be possible. The motor shall have adequate thermal rating for this duty.
- c) After failure of power supply to the motor one close open operation shall be possible with the energy contained in the operating mechanism.
- d) Breaker operation shall be independent of the motor which shall be used solely for compressing the closing spring. Facility for manual charging of the closing spring shall also be provided. The motor rating shall be such that it required preferably not more than 60 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 and remote control cabinet.
- 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.

11.8.4. 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 lost 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.

11.9. ADDITIONAL DATA TO BE FURNISHED ALONGWITH THE OFFER :

- a) Drawing showing contacts in close, arc initiation, full arcing, arc extinction and open position.
- b) Data on capabilities of circuit breakers in terms of time and number of operations at duties ranging from 100 fault currents to load currents of the lowest possible value without requiring any maintenance or checks.
- c) Curves supported by test data indicating the opening time under close open operation with combined variation of trip coil voltage and hydraulic pressure.

11.10. TESTS

11.10.1. In accordance with the requirements stipulated under Section GTR the circuit breaker alongwith its operating mechanism shall conform to the type tests as per IEC-62271-100.

11.10.2. 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. Speed curves for each breaker shall be obtained with the help of a suitable operation analyzer to determine the breaker contact movement during opening, closing, auto-reclosing and trip free operation under normal as well as limiting operating conditions (control voltage, pneumatic pressure etc.). The tests shall show the speed of contacts directly at various stages of operation, travel of contacts, opening time, closing time,

shortest time between separation and meeting of contacts at break make operation etc. This test shall also be performed at site for which the necessary operation analyzer alongwith necessary transducers, cables, console etc. shall be furnished as mandatory maintenance equipment.

11.10.3 TECHNICAL PARAMETERS 400 kV CIRCUIT BREAKER:

a)	Rated voltage kV (rms)	420
b)	Rated frequency (Hz)	50
c)	No. of poles	3
d)	Type of circuit breaker	SF6 insulated.
e)	Rated continuous current (A) at an ambient temperature of 50°C	3150/4000 A (for line, transformer & Reactor, bus coupler bay breaker)
f)	Rated short circuit capacity	63kA/50kA with percentage of DC component as per IEC-62271-100 corresponding to minimum opening conditions as specified
g)	Symmetrical interrupting capability kA (rms)	63kA/50kA
h)	Rated short circuit making current kAp	157.5kA/125kA
i)	Short time current carrying capability for Three second kA (rms)	63kA/50kA
j)	Rated line charging interrupting current at 90 degree leading power factor angle (A rms)	As per IEC
	(The breaker shall be able to interrupt the rated line charging current with test voltage immediately before opening equal to the product of $U/\sqrt{3}$ and 1.4 as per IEC-62271-100	
k)	First pole to clear factor	1.3
l)	Rated break time as IEC (ms)	40
m)	Total break time (ms)	45
n)	Total closing time (ms)	Not more than 150
o)	Rated operating duty cycle	O-0.3s –CO-3 min-CO
p)	Reclosing	Single phase & Three phase

		auto reclosing.
q)	Pre-insertion resistor requirement (If required) 1). Rating (ohms) 2). Minimum pre-insertion Times (ms) 3). Opening of PIR contacts	400 8 a) PIR contacts should open immediately after closing of main contacts. b) Atleast 5 ms before opening of main contacts at rated air/gas pressure, where the PIR contact remain closed.
r)	Rated insulation levels Full wave impulse withstand (1.2x50micro sec.)	
	Between lines terminals and ground:	±1425 kVp
	Between terminals with circuit breaker open:	±1425 kVp impulse on one terminal & 240kVp of opposite polarity on the other terminal.
s)	Rated switching impulse withstand voltage (250/2500 micro-sec) Dry & wet. Between terminals with circuit breaker open:	1050kVp ±900 kVp impulse on one terminal & 345kVp of opposite polarity on the other terminal.
t)	One minute power frequency withstand voltage. • Between line • terminals and ground • Between terminals with circuit breaker open.	650kV rms. 815kV rms.
u)	Max. radio interference voltage for frequency between 0.5 MHz and 2 MHz at 266kV(Micro volts)	1000
v)	Max. difference in the instants of closing/opening of contacts (ms) between poles.	As per IEC
w)	Trip coil and closing coil voltage	220V DC with variation as specified in Sec GTR
x)	Auxiliary contacts Auxiliary switch shall also comply with	Each circuit breaker pole shall be provided with an auxiliary

	requirements as given. Independent single pole reversible contacts (from NO to NC & vice versa.	switch with 20% of spare – NO & 20% spare NC contacts for use in future.
y)	Rating of auxiliary contacts Breaking capacity of auxiliary contacts less than 20 ms. System neutral earthing	10A at 220V DC 2A DC with the circuit time constant of not less than 20ms. Effectively earthed.
z)	Mechanical & Electrical endurance class	M2-C2

245 kV CIRCUIT BREAKER:

a)	Rated voltage kV (rms)	245
b)	Rated frequency (Hz)	50
c)	No. of poles	3
d)	Type of circuit breaker	SF6 insulated.
e)	Rated continuous current (A) at an ambient temperature of 40°C	1600/3000 A (3000 for bus coupler breaker)
f)	Rated short circuit capacity	50/40kA (As applicable) with percentage of DC component as per IEC-62271-100 corresponding to minimum opening conditions as specified
g)	Symmetrical interrupting capability kA (rms)	50/40 kA(As applicable)
h)	Rated short circuit making current kAp	125/100kA(As applicable)
i)	Short time current carrying capability for Three second kA (rms)	50/40 kA(As applicable)
j)	Rated line charging interrupting current at 90 degree leading power factor angle (A rms)	As per IEC
	(The breaker shall be able to interrupt the rated line charging current with test voltage immediately before opening equal to the product of $U/\sqrt{3}$	

	and 1.4 as per IEC-62271-100	
k)	First pole to clear factor	1.3
l)	Rated break time as IEC (ms)	60
m)	Total break time (ms)	65
n)	Total closing time (ms)	Not more than 200
o)	Rated operating duty cycle	O-0.3s –CO-3 min-CO
p)	Reclosing auto reclosing	Single phase / Three phase auto reclosing.
q)	Rated insulation levels	
	i) Full wave impulse withstand voltage (1.2x50micro sec.)	
	• Between lines terminals and ground:	±1050 kVp
	• Between terminals with circuit breaker open:	±1050 kVp
	ii) One minute power frequency withstand voltage.	
	• Between line terminals and ground	460kV rms.
	• Between terminals with circuit breaker open.	530kV rms.
r)	Max. radio interference voltage for frequency between 0.5 MHz and 2 MHz at 156kV(Micro volts)	1000
s)	Max. difference in the instants of closing/opening of contacts (ms) between poles.	As per IEC
t)	Trip coil and closing coil voltage	220V DC with variation as specified in Sec GTR
u)	Auxiliary contacts Auxiliary switch shall also comply with requirements as given. Independent single pole reversible contacts (from NO to NC & vice versa.	Each circuit breaker pole shall be provided with an auxiliary switch with 20% of spare – NO & 20% spare NC contacts for use in future.
	Rating of auxiliary contacts	10A at 220V DC
	Breaking capacity of auxiliary contacts less than 20 ms.	2A DC with the circuit time constant of not less than 20ms.
v)	System neutral earthing	Effectively earthed.

w)	Mechanical & Electrical endurance class	M2-C2
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12. DISCONNECTORS (ISOLATORS)

12.1. General

Disconnectors shall be of the single-pole, group operated type, installed in the switchgear to provide electrical isolation of the circuit breakers, the transformers, shunt reactor, double bus and transmission lines. The disconnectors shall conform to IEC-62271-102 and shall have the following ratings as specified.

Technical Parameter

Sl. No.	Particulars	400kV	220kV
a)	Rated voltage (rms) Un	420kV	245kV
b)	Rated frequency	50Hz	50-Hz
c)	System earthing	Effectively earthed	Effectively earthed
d)	Type	SF6 insulated	SF6 insulated
e)	Rated continuous current (A) at an ambient temperature of 40°C	3150/4000A (for line, Transformer & reactor / bus coupler / bay)	1600/3000 A (for line / bus coupler)
f)	Rated short time withstand current of isolator and earth switch	50/40kA for 1 sec. (As applicable)	50/40kA for 1 sec. (As applicable)
g)	Rated dynamic short circuit withstand current of isolator & earth switch	125/100kAp (as applicable)	125/100kAp (as applicable)
h)	Rated insulation level: One minute power frequency withstand voltage		
	To earth:	650kV rms	460kV rms
	Across isolating distance	815kV rms	530kV rms
	Rated insulation level: 1.2/50micro sec. lighting impulse withstand voltage (+ve or -ve polarity)		
	To earth:	1425kVp	1050kVp
	Across isolating distance	±1425 ±240kVp	±1200kVp
	Rated switching impulse		

	withstand voltage (250/2500 micro. Sec.) dry & wet		
	Between line terminals & ground	±1050kVp	NA
	Between terminals with isolator open	±900kVp impulse on one terminal & 345kVp of opposite polarity on the other terminal	NA
i)	Rated mechanical terminal load	As per IEC	As per IEC
j)	No. of spare auxiliary contacts on each isolator	4 NO & 4NC	4 NO & 4NC
k)	No. of spare auxiliary contacts on each earthing switch	4 NO & 4NC	4 NO & 4NC
l)	A. Mechanical endurance class of disconnecter. B. Electrical endurance class of earthing switches. i. High speed earthing switch with short circuit making capability. ii. Maintenance earthing switch	M2 (10,000) E1/E2 E0	M2 (10,000) E1/E2 E0

12.2. Construction & Design.

12.2.1. The single pole group operated disconnectors shall be operated by electric motor suitable for use on 220 v 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.

12.2.2. Disconnectors shall be suitable to switch the bus charging currents during their opening and closing and shall conform to all test duties 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 busbars 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.

- 12.2.3. The disconnecting switches shall be arranged in such a way that all the three phases operate simultaneously. All the parts of the operating mechanism shall be able to withstand starting torque of the motor mechanism without damage until the motor overload protection operates.
- 12.2.4. It shall be possible to operate the disconnecting switches manually by cranks or handwheels. The contacts shall be both mechanically and electrically disconnected during the manual operation.
- 12.2.5. The operating mechanisms shall be complete with all necessary linkages, clamps, couplings, operating rods, support brackets and grounding devices. All the bearings shall be permanently lubricated or shall be of such a type that no lubrication or maintenance is required.
- 12.2.6. The opening and closing of the disconnectors shall be achieved by either local or remote control. The local operation shall be by means of a two-position control switch located in the bay module control cabinet.
- 12.2.7. Remote control of the disconnectors from the control room shall be made by means of remote/ local transfer switch.
- 12.2.8. The disconnector operations shall be inter-locked electrically with the associated circuit breakers in such a way that the disconnector control is inoperative if the circuit breaker is closed.
- 12.2.9. Each disconnector shall be supplied with auxiliary switch having four normally open and four normally closed contacts for future use over and above those required for switchgear interlocking and automation purposes. The auxiliary switch contacts are to be continuously adjustable such that, when required, they can be adjusted to make contact before the main switch contacts.
- 12.2.10. The signaling of the closed position of the disconnector shall not take place unless it is certain that the movable contacts will reach a position in which the rated normal current, peak

withstand current and short-time withstand current can be carried safely.

- 12.2.11. The signaling of the open position of the disconnecter 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.
- 12.2.12. All auxiliary switches and auxiliary circuits shall be capable of carrying a current of at least 10 A DC continuously.
- 12.2.13. The auxiliary switches shall be capable of breaking at least 2 A in a 220 V DC circuit with a time constant of not less than 20 milliseconds.
- 12.2.14. The disconnectors and safety grounding switches shall have a mechanical key (pad locking key) and electrical inter-locks to prevent closing of the grounding switches when isolator switches are in the closed position and to prevent closing of the disconnectors when the grounding switch is in the closed position.
- 12.2.15. The local control of the Isolator and high-speed grounding switches from the bay module control panel should be achieved from the individual control switches with the remote/local transfer switch set to local.
- 12.2.16. All electrical sequence interlocks will apply in both remote and local control modes.
- 12.2.17. Each disconnector shall have a clearly identifiable local, positively driven mechanical position indicator, together with position indicator on the bay module control cabinet and provisions for taking the signals to the control room. The details of the inscriptions and colouring for the indicator are given as under :

COLOUR		SIGN
Open position	Open	Green
Closed position	Closed	Red

- 12.2.18. 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.

- 12.2.19. The disconnecting switches shall be provided with rating plates and shall be accessible for inspection.
- 12.2.20. The disconnecting switches shall be capable of being padlocked in both the open and closed positions with the operating motor automatically disengaged. The padlocking device shall be suitable for a standard size lock with a 10 mm shank. The padlock must be visible and directly lock the final output shaft of the operating mechanism. Integrally mounted lock when provided shall be equipped with a unique key for such three phase group. Master key is not permitted.
- 12.2.21. Tests: The disconnectors & earth switch shall confirm to type tests and shall be subjected to routine test in accordance with IEC – 62271-100/102

13. SAFETY GROUNDING SWITCHES

- 13.1. Three-pole, group operated, safety grounding switches shall be operated by electric motor for use on 220 V DC ungrounded system and shall be equipped with a manual operating mechanism for emergency use. The motor shall be protected against over-current and short circuit.
- 13.2. Each safety grounding switch shall be electrically interlocked with its associated disconnecter and circuit breaker such that it can only be closed if both the current breaker and disconnecter are in open position. Safety grounding switch shall also be mechanically key interlocked with its associated disconnecter.
- 13.3. Each safety grounding switch shall have clearly identifiable local positive driven mechanical indicator together with position indicator on the bay module control cabinet and provision for taking the signal to Control room.
- 13.4. The details of the inscription and colouring for the indicator are given as under :

SIGN

COLOUR

Open position
Closed position

Open
Closed

Green
Red

- 13.5. Interlocks shall be provided so that manual operation of the switches or insertion of the manual operating device will disable the electrical control circuits.
- 13.6. Each ground switch shall be fitted with auxiliary switches having four normally open and four normally closed contacts for use by others over and above those required for local interlocking and position indication purposes.
- 13.7. Provision shall be made for padlocking the ground switches in either the open or closed position.
- 13.8. 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.
- 13.9. The main grounding connections on each grounding switch shall be rated to carry the full short circuit rating of the switch 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.
- 13.10. The safety grounding switches shall conform to the requirements of IEC- 62271- 102
- 13.11. Mechanical position indication shall be provided locally at each switch and remotely at each bay module control cabinet/ substation automation system.

14. HIGH SPEED MAKE PROOF GROUNDING SWITCHES:

Grounding switches located at the beginning of the line feeder bay modules shall be of the high speed, make proof type and will be used to discharge the respective charging currents, in addition to their safety grounding function. These grounding switches shall be capable of interrupting the inductive currents and to withstand the associated TRV.

Single phase switches shall be provided with operating mechanism suitable for operation from a 220V DC.

The switches shall be fitted with a stored energy closing system to provide fault making capacity.

The short circuit making current rating of each ground switch shall be at least equal to its peak withstand current rating of 125/100 kA (As applicable). The switches shall have inductive/ capacitive current switching capacity as per IEC-62271-102.

Each high speed make proof grounding switch shall have clearly identifiable local positive driven mechanical indicator together with position indicator on the bay module control cabinet and provision for taking the signal Control Room.

The details of the inscription and colouring for the indicator shall be as under:-

	SIGN	COLOUR
OPEN POSITION	Open	Green
CLOSED POSITION	Closed	Red

High speed ground switch operation should be possible locally from the bay module control cabinet, or remotely from the control room in conjunction with opening of the associated disconnector.

These high speed grounding switches shall be electrically interlocked with their associated circuit breakers and disconnectors so that the grounding switches can not be closed if the circuit breakers and disconnectors are closed.

Interlocks shall be provided so that the insertion of the manual operating devices will disable the electrical control circuits.

Each high speed ground switch shall be fitted with auxiliary switches having four NO & four NC auxiliary 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 bay control cabinet. Provision shall be made for padlocking the ground switches in their open or closed position.

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.

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.

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

15. INSTRUMENT TRANSFORMERS

15.1. Instrument Transformers

15.1.1. Current Transformers

A) General :

- i) The current transformers and accessories shall conform to IEC : 61869-2/1 and other relevant standards except to the extent explicitly modified in the specification.
- ii) The particulars of the various cores may change within reasonable limits as per the requirements of protection relay supplier. The manufacturer is required to have these values confirmed from the purchaser before proceeding with design of the cores. The other characteristics of CTs shall be as given in TECHNICAL PARAMETER of Current Transformer.

B) Ratios and Characteristics

The number, rating, ratios, accuracy class, etc. for the individual current transformers secondary cores shall be in accordance with Table-IA & 1B Where multi-ratio current transformers are required the various ratios shall be obtained by changing the effective number of turns on the secondary winding.

C) Rating and Diagram Plates

Rating and diagram plates shall be as specified in the IEC specification incorporating the year of manufacture. The rated extended current rating voltage and rated thermal current shall also be marked on the name plate.

The diagram plates shall show the terminal markings and the

relative physical arrangement of the current transformer cores with respect to the primary terminals (P1 & P2).

The position of each primary terminal in the current transformer SF6 gas section shall be clearly marked by two plates fixed to the enclosure at each end of the current transformer.

D) Constructional Details:

- a) The current transformers incorporated into the GIS will be used for protective relaying and metering and shall be of metal-enclosed type. All the current transformers shall have effective electromagnetic shields to protect against high frequency transients.
- b) Each current transformer shall be equipped with a marshalling 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 primary current shall be 150% at highest ratio and 200% at ratios other than highest ratios.
- e) 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 built in construction of the CTs.
- f) The wiring diagram, for the interconnections of the three single phase CTs shall be provided inside the marshalling box.
- g) The current transformers shall be suitable for high speed auto-reclosing.
- i) Provisions shall be made for primary injection testing either within CT or outside.
- ii) Electromagnetic shields to be provided against high frequency transients typically 1-30 Hz.

15.1.2. VOLTAGE TRANSFORMERS

A) General

The voltage transformers shall conform to IEC- 61869-3/1 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. However, for 400 kV on the lines outdoor type Capacitive Voltage Transformers suitable for carrier coupling shall be provided.

B) Ratios and Characteristics

The rating, ratio, accuracy class, connection etc. for the voltage transformers shall be in accordance with Table II-A and Table II-B.

C) 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.

D) Secondary Terminals, Earthing and Fuses

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.

E) The transformer shall be able to sustain full line to line voltage without saturation of transformer.

The accuracy class will be at maximum tap.

F) Constructional Details of Voltage Transformers :

- a) The voltage transformers shall be located in a separate bay module on the bus 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 voltage transformers shall have three secondary windings
- c) Voltage transformers secondaries shall be protected by HRC cartridge type fuses/MCB for all the windings. In addition fuses

shall be provided for the protection and metering windings for fuse monitoring scheme. The secondary terminals of the VT's shall be terminated to the stud type non-disconnecting terminal blocks in the secondary boxes via the fuse/MCB.

- d) The voltage transformer should be thermally and dielectrically safe when the secondary terminals are loaded with the guaranteed thermal burdens.
- e) The accuracy of 0.2 on secondary III should be maintained through out the entire burden range upto 100 VA on all the three windings without any adjustments during operation.
- f) The diagram for the interconnection of the VTs shall be provided inside the marshalling box.

15.1.3. TESTS:

Current and voltage transformers shall conform to type tests and shall be subjected to routine test in accordance with IEC.

15.1.4 TECHNICAL PARAMETERS

15.1.4.1 Current Transformers

Sl. No.	Particulars	400kV	220kV
a	Rated Voltage Un	420 kV (rms)	245 kV (rms)
b	Rated frequency	50hZ	50hZ
c	System neutral earthing	Effectively earthed	Effectively earthed
d	Rated short time thermal current	50kAp. for 1 second.	50/40 kAp. (as applicable) for 1 second.
e	Rated dynamic current	125 kAp. for 1 second	125/100 kAp. (As applicable) for 1 second
f	Rated insulation levels 1) 1.2/50 micro second impulse voltage 2) 1 minute power frequency withstand voltage 3) 250/2500micro second switching impulse voltage (Dry & wet)	± 1425 kVp 650 kV (ram) 1050kVp	± 1050 kVp 460kv (rms)
g	Maximum temperature rise over an ambient temperature of 40°C	As per IEC 61869-2/1	As per IEC 61869-2/1
h	Radio interference voltage at $1.1U_n/\sqrt{3}$ and frequency range 0.5 to 2	1000 microvolts	1000 microvolts

	MHz		
i	One minute power frequency withstand voltage between secondary terminal and earth	3kV (rms)	3kV (rms)
j	Partial discharge level	10 pico coulombs	10 pico coulombs

15.1.4.2 Voltage Transformers

Sl. No.	Particulars	400kV	220kV
a	Rated System Voltage Un	420 kV (rms)	245 kV (rms)
b	Rated frequency	50hZ	50hZ
c	System neutral earthing	Effectively earthed	Effectively earthed
d	System fault level	50 kAp. for 1 second.	50/40 kAp. (as applicable) for 1 second.
e	Rated insulation levels 1) 1.2/50 micro second impulse voltage 2) 1 minute power frequency withstand voltage 3) 250/2500micro second switching impulse voltage (Dry & wet)	± 1425 kVp 650 kV (ram) 1050kVp for 400kV system	± 1050 kVp 460kv (rms)
f	One minute power frequency withstand voltage for secondary winding	3KV(rms)	3kV (rms)
g	Radio interference voltage at $1.1U_n/\sqrt{3}$ and frequency range 0.5 to 2 MHz	1000 microvolts	1000 microvolts
h	Rated total thermal burden	400VA	400VA
i	Partial discharge level	10 pico couloms	10 pico couloms

16 OUTDOOR BUSHINGS :

A) General

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 publication 60137 as applicable.

B) 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.

C) Bushing types and fitting

Condenser type bushings will be preferred but alternative types can also be considered. Liquid filled bushings shall be provided with liquid level gauges clearly visible from ground level, preferably of the direct reading prismatic type or the magnetic type. Other types of liquid level gauges will only be accepted if specifically approved.

D) Mechanical forces on bushing terminals

Outdoor bushings must be capable of withstanding cantilever forces due to weight of busduct and short circuit forces. Design calculations in support of the cantilever strength chosen shall be submitted for owners review and approval.

E) The major parameters of the bushings shall be as follows:-

i	Rated Voltage (kv)	420 kV	245 kV
ii	Rated current (Amp)	3150/2000 (as applicable)	1600
iii	Lightning impulse withstand voltage (kVp)	1425	1050
iv	Switching impulse withstand voltage (kVp)	1050	-
v	One minute power frequency withstand voltage kV (rms)	650	460
vi	Minimum total creepage distances (mm)	10500	6125

17 Surge Arrestors

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

17.1 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 bidders feels that at some more locations the surge arrestors are required to be provided the same should also be included in the offer.

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

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.

17.2 Duty requirements

- a) The surge arrester shall be of heavy duty station class and gapless (Metal oxide) type without any series or shunt gaps.
- b) The surge arresters shall be capable of discharging over-voltages occurring during switching of unloaded transformers, reactors and long lines.
- c) 420 kV class Surge arresters shall be capable of discharging of severe re-energisation switching surges on a 400 kV, 450 Km long line with surge impedance of 300 ohms and capacitance of 12 nF/Km and over voltage factor of 2.3 p.u
- d) 420 kV class arrester shall be capable of discharging energy equivalent to class 4 of IEC for a 420 kV system on two successive operation followed immediately by 50 HZ energisation with a sequential voltage profile as specified below:
 - 705 kVp for 3 peaks
 - 580 kVp for 0.1 Sec.
 - 565 kVp for 1 Sec.
 - 550 kVp for 10 Secs.
- e) 245 kV class arrester shall be capable of discharging energy equivalent to class 3 of IEC for 245 kV system on two

successive operations.

- f) The reference current of the arresters shall be high enough to eliminate the influence of grading and stray capacitance on the measured reference voltage.
- g) The surge arresters are being provided to protect the followings whose insulation levels are indicated in the table given below:-

Equipment to be protected	Lightning impulse (kVp) for 420kV system	Switching surge (kVp) for 420kV system	Lightning impulse (kVp) for 245kV system
Power transformer	± 1300	± 1050	± 950
Instrument transformer	± 1425	± 1050	± 1050
Reactor	± 1300	± 1050	-
CB/Isolator phase to ground	± 1425	± 1050	± 1050
Across open contacts	± 1425 (±240)	± 900 (± 345)	± 1200

17.3 Constructional Features

The nonlinear blocks shall be of inferred metal oxide material. These shall be provided in such a way as to obtain robust construction, with excellent mechanical and electrical properties even after repeated operations. The arrester enclosure shall be vertically or horizontally mounted to suit the layout of the switchgear as suggested by the manufacturer and shall be fitted with a discharge counter located in an easily accessible position. The main grounding connection from the surge arrester to the earth shall be provided by the bidder. The size of the connecting conductor shall be such that all the energy is dissipated to the ground without getting overheated.

17.4 Tests

In accordance with the requirements stipulated the surge arresters shall conform to type tests and shall be subjected to routine and acceptance tests in accordance with IEC document. Each metaloxide block shall be tested for the guaranteed specific energy capability in addition to the routine/acceptance test as per IEC-60099.

17.5 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.

17.6 Parameters

Following are the parameters for 400kV and 220 kV system generally adopted by Owner for their installations. These parameters are indicative and not binding. The actual parameters required for the installation shall be evolved by contractor.

420KV & 220KV CLASS SURGE ARRESTOR

Sl. No.	Particulars	400kV	220kV
a)	Rated System Voltage	420 kV	245 kV
b)	System neutral earthing	Effectively earthed	Effectively earthed
c)	Rated arrester voltage	390kV	216kV
d)	Nominal discharge current	10kA of 8/20 micro second wave	10kA of 8/20 micro second wave
e)	Rated frequency	50Hz	50Hz
f)	Minimum discharge capability voltage corresponding to minimum discharge characteristics	8 KJ/kV or corresponding to Cl. 3.4.1 (d) to rated arrester voltage and at minimum discharge characteristics whichever is higher.	5KJ/kV (referred to rated arrester)
g)	Continuous operating voltage at 50°C	303kV	168kV
h)	Min. switching surge residual voltage (1kA) Max. switching surge residual voltage (1kA)	730kVp 780kVp	- 500kVp
i)	Max. residual voltage at (i). 5kA (ii). 10kA nominal discharge current (iii). 20kA nominal discharge current	- 900kVp 975kVp	560kVp 600kVp -
j)	Long duration discharge class	4	3
k)	High current short duration test value (4/10 micro sec. wave)	100kAp	100kAp
l)	Current for pressure relief test	40kA rms	40kA rms
m)	Prospective symmetrical fault current	40kA rms for 0.2 Sec.	40kA rms for 0.2 Sec.
n)	Pressure relief class	A	A

o)	RIV at $1.1U_n/\sqrt{3}$ kV rms (micro volts)	Less than 500	Less than 500
p)	Partial discharge at 1.05 COV	Not more than 50	Not more than 50
q)	Reference ambient temp.	50°C	50°C

18 400 kV & 220 kV GIS BUILDING (If applicable):

- a) The buildings shall house 400 KV and 220 KV Gas Insulated Switchgear (GIS) separately and other associated equipments inside in each of the GIS building.
- b) The bidder shall submit the design & construction proposal of the building along with necessary information, data, and drawings in the techno- commercial bid according to the complete requirements.
- c) The dimensions for 400 KV & 220 KV GIS building is indicated in the enclosed layout plan. The dimension given is for reference only and may vary according to requirement of the equipment to be installed inside. The bidder shall finalize the dimensions according to the equipment offered by them providing enough space & access for erection, operation and maintenance. The dimensions indicated in the tender drawing is only indicative and minimum required. (Refer Annexure V of projects).

19.0 Seismic Design Criteria:

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 non concurrently. Seismic level Zone- II as per new IS-1893, latest edition has to be considered for the design of equipment. The seismic loads shall be equal to static loads corresponding to the weight of the parts multiplied by the acceleration. The equipments along with its parts shall be strong enough and sufficiently well connected to resist total operating stresses resulting from the forces in normal operation but in case of abnormal condition shall also resist with forces superimposed due to earthquakes. The copies of type test reports for similar rated equipment, if tested earlier, should be furnished along with the tender. If the equipment has not been type tested earlier, design calculations of simulated parameters should be furnished along with the offer.

To prevent the movement of GIS sub assemblies i.e. various bay

modules during the earthquake, suitable devices shall be provided for fixing the sub assemblies to the foundation. The contractor shall supply necessary bolts for embedding in the concrete foundation. The fixing of GIS sub assemblies to the foundation shall be designed to with-stand the seismic events. It will also be ensured that the special devices as well as bolts shall not be over stressed. The details of the devices used and the calculations for establishing the adequacy shall be furnished by the supplier and shall be subject to the purchase's approval.

20.0 PARTIAL DISCHARGE MONITORING SYSTEM & DEW POINT METER

Online P.D meter, Online SF6 & O2 monitoring & alarm system and Dew point meter shall be offered as per relevant schedule of BPS and shall be considered for evaluation of bid. The specifications are enclosed at Annex-A1. Contractor shall provide adequate number of UHF sensors in the offered GIS for connection to the Online PD meter & the number & location of these sensors shall be subject to approval of the purchaser.

21.0 QUALITY OF SF6 GAS

- a) 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 as above as a minimum & should be suitable in all respects for use in the switchgear under all operating conditions.
- b) The high pressure cylinders in which SF6 gas is supplied & stored at site shall comply with the requirements of following standards & regulations :

IS : 4379 Identification of the contents of industrial gas cylinders.

IS : 7311 Seamless high carbon steel cylinders for permanent & high pressure liquefiable gases. The cylinders shall also meet Indian Boilers Regulations. (Mandatory)

c) Test

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 owner indicating all test results as per IEC standards for each lot of SF6 gas. Further site tests for moisture, air content, flash point and dielectric strength to be done during commissioning of GIS. Gas bottles should be tested for leakage during receipt

at site.

- d) The bidder shall indicate diagnostic test methods for checking the quality of gas in the various sections during service. The method proposed shall, as a minimum check the moisture content & the percentage of purity of the gas on annual basis.
- e) The bidder shall also indicate clearly the precise procedure to be adopted by maintenance personnel for handling equipment that are exposed to the products of arcing in SF₆ Gas so as to ensure that they are not affected by possible irritants of the skin and respiratory system. Recommendations shall be submitted for suitable protective clothing, method of disposal of cleaning utensils and other relevant matters.
- f) The bidder shall also indicate the details and type of filters used in various gas sections, and should also submit the operating experience with such filters.

22 SF6 GAS MONITORING DEVICES AND ALARM CIRCUITS:-

22.1 Dial type temperature compensated gas density or density monitoring devices with associated pressure gauge will be provided. The devices shall provide continuous & automatic monitoring of the state of the gas & a separate device shall be provided for each gas compartment so that each compartment can be monitored simultaneously as follows:-

1) Compartments except circuit breaker

a) Gas Refill level

This will be used to annunciate the need for the gas refilling. The contractor shall provide a contact for remote indication.

b) 'Zone Trip' level

This is the minimum level at which the manufacturer will guarantee the insulation rating of the assembly. Contacts shall be in accordance with requirement.

2) Circuit Breaker

a) 'Gas Refill' level

This will be used to annunciate the need for gas refilling. The contractor shall provide contact for remote indication.

b) '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 & the tripping & closing circuit shall be blocked.

c) 'Zone Trip' level

This is the minimum level at which the manufacturer will guarantee the insulation rating of the assembly. Contacts shall be in accordance with requirement. The bidder should furnish temperature v/s pressure curves for each setting of density monitor along with details of the monitoring device. It shall be possible to test all gas monitoring relays/devices without de-energizing the primary equipment & without reducing pressure in the main section. Plugs & sockets shall be used for test purposes. It shall also damp the pressure pulsation while filling the gas in service, so that flickering of the pressure switch contacts does not take place.

3)

- a. The gas density and pressure sensitive devices, together with all relays supplied by the manufacturer for use in protection, shall be approved by the PURCHASER. It shall be possible to test all gas monitoring relays without de-energizing the primary equipment and without reducing pressure in the main section. Disconnecting type plugs and sockets shall be used for test purposes; the pressure/density device shall be suitable for connecting to the male portion of the plug.
- b. Two potential free electrical contacts shall be provided with each and every alarm condition. These are to be grouped together and wired to the cable termination blocks in the local control panels to give remote alarm indications/annunciation's the remote panels. The BIDDER will be advised of the grouping required after the contract has been placed. Provision shall be made for display of gas pressure of all individual gas compartment in the remote panel/HMI. The density monitor shall be provided with necessary signal Transmitter (mA) for display of actual gas pressure in the remote HMI.
- c. BIDDER shall advise if the breakers are suitable for breaking the load current even if SF-6 gas pressure has reduced to atmospheric pressure.

22.2

a) Gas Leakage

The maximum gas leakage shall not exceed 0.5% (half percent) per year for the whole equipment and for any individual gas

compartment separately.

b) Gas Supply

The contractor shall include the supply of all SF6 gas necessary for filling & putting into operation the complete switchgear installation being supplied. In addition 20% of total gas requirement shall be supplied in separate cylinders as spare requirement, over & above the requirement of gas for successful commissioning. Pl. refer list of mandatory spares in this connection.

23 GAS FILLING AND EVACUATING PLANT:-

All the plant necessary for filling and evacuating the SF6 gas in the switchgear shall be supplied with the contract 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 when carrying out maintenance or repair work on the switchgear and associate equipment of at least one complete bay. Where any item of the filling and evacuating plant is of such a weight that it cannot easily be carried by maintenance personnel, it shall be provided with lifting hooks for lifting and moving with the overhead cranes. The capacity of evacuation plant will be as under :

Vacuum Pump: 40 M³/Hour(Nominal suction pressure)

Compressor: 15 M³/Hour(Delivery)

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. The gas compartments shall preferably be fitted with permanent non-return valves through which the gas is pumped into or evacuated from the compartments. Details of the filling and evacuating plant that will be supplied, as well as the description of the filling and evacuating procedures shall be provided along with the bid.

24 SF6 GIS to XLPE Cable Termination (If Applicable):

The 220 kV underground cables are to be connected to 220 kV GIS by the interfacing of XLPE cable sealing end to GIS Cable termination enclosure for making connection 1C x 1000 sq mm (As applicable) XLPE cable. Cable termination kit shall be

supplied by cable supplier. The ducts and the casing shall be suitable for the requirements for which it is designed. This interface section shall be designed in a manner which will allow ease of operation and maintenance.

The SF6 GIS to XLPE cable termination shall conform to IEC-62271-209(latest edition).

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 bidder 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.

All supporting structures for the SF6 bus-duct connections between the XLPE cable sealing ends and the GIS shall be supplied by the supplier. The supplier may specify alternative connecting & supporting arrangements for approval of the purchaser.

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 typical arrangement drawing of interconnecting bus-duct from GIS bay module to XLPE cable termination end shall be submitted along with offer.

25 Electric Overhead Crane (If applicable):

One EOT Crane each for 400kV & 220kV GIS hall of suitable capacity shall be provided for erection & maintenance of largest GIS component/assembly. The crane shall consist of all special requirements for erection & maintenance of GIS equipments.

The crane shall be possible to be operated through the cable & through the pendant control or through remote control device, which shall be easily accessible from the floor of GIS building.

26 The crane for 400kV GIS hall shall have capacity of minimum 6T safe working load & minimum height of crane shall be 9.0 meters or as per actual requirement whichever is higher.

The crane for 220kV GIS hall shall have capacity of minimum 5T sage working load & minimum height of crane shall be 8.0 meters or as per actual requirement whichever is higher.
EOT Crane shall be provided with Double Girder type.

27 TRANSFORMER / REACTOR TERMINATION MODULE (if applicable):-

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 fittings.

OR

The oil filled transformers and reactors are as shown in the sub-station SLD. The oil to air bushings of the 400/220/33kV autotransformers and 400kV reactors shall be supplied by the respective supplier's and the same shall be connected to the SF6 ducts through air to SF6 bushings to be provided under present scope.

28 PAINTING OF ENCLOSURE:-

All enclosures shall be painted externally as per manufacturer's painting procedure. The painting procedures as followed shall be enclosed with the bid.

29 HEATERS

Wherever required, heaters shall be provided to prevent moisture condensation. Heaters are not allowed in side the main circuit.

30 IDENTIFICATION & RATING PLATE

- i) Each bay shall have a nameplate showing
 - a) A listing of the basic equipment from air entrance bushing to air entrance bushing such as a breaker, disconnectors grounding switches, current transformers, voltage transformers, and bushings).
 - b) A schematic diagram indicating their relative locations.
 - c) KPTCL Contract Number.
- ii) Each module will have its own Identification & rating plate.

The rating plate marking for each individual equipments like circuit breaker, disconnectors grounding switches, current transformer, voltage transformers, surge arrester etc shall be as per their relevant IEC.

31. TRANSPORTATION 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, disconnectors, earth switches, surge arrestors and bus sections exceeding 3 metres length shall be provided with sufficient number of electronic impact recorders (on returnable basis) during transportation to measure the magnitude and duration of the impact in all three directions. The acceptance criteria and limits of impact in all three directions which can be withstood by the equipment during transportation and handling shall be submitted by the contractor during detailed engineering. The recording shall commence in the factory and must continue till the units reach site. The data of electronic impact recorders shall be downloaded at site and a soft copy of it shall be handed over to Engineer – in –charge. Further, within three weeks the contractor shall communicate the interpretation of the data.

32. PACKING, STORAGE AND UNPACKING.

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.

The SF6 metalclad 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. 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.

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.

Special precautions shall be taken to protect any parts containing electrical insulation against the ingress of moisture. This applies particularly to the metalclad equipment of which each gas section shall be sealed and pressurized prior to shipping. Either dry nitrogen/air or dry SF₆ gas shall be used and the pressure shall be such as to ensure that, allowing for reasonable leakage, it will always be greater than the atmospheric pressure for all variations in ambient temperature and the atmospheric pressure encountered during shipment to site and calculating the pressure to which the sections shall be filled to ensure positive pressure at all times during shipment. The type of gas, the maximum pressure to which sections will be filled prior to shipment and the minimum allowable pressure during shipment shall be advised prior to dispatch.

All blanking plates, caps, seals, etc., necessary for sealing the gas sections during shipment to site shall be provided as part of the contract and shall remain the property of KPTCL. If considered necessary, blanking plates or other sealing devices shall be provided with facilities for measuring the gas pressure and recharging at any time during the transport period. Any seals, gaskets, 'O' rings, etc. that may be used as part of the arrangement for sealing off gas sections for shipment of site, shall not be used in the final installation of the equipment at site. Identification serial numbers shall be stamped into the blanking plates, etc., and on the switchgear equipment to which they are fitted so that they can easily be identified and refitted should it ever be necessary to ship sections of the switchgear back to the manufacturer's works for repair.

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.

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.

The contractor will be able to use the available storage areas at site.

The contractor shall ensure that during the period between arrival at site and erection, all materials and parts of the contract works are suitably stored in such approved manner as to prevent damage by weather, corrosion, insects, vermin or fungoral growth. The scope of providing the necessary protection, storing off the ground, as required etc. is included in the works to be performed by the contractor.

The equipment shall only be unpacked or removed from the containers immediately prior to being installed. They shall not be left lying unnecessarily in open crates or containers. Special precautions shall be taken when gas sections which have been sealed and pressurized for shipping are opened up to reduce the ingress of dirt and atmospheric moisture to a minimum. Whenever possible this shall only be done immediately prior to installation and if any section is to be left outside for any length of time after being opened, it shall be resealed and pressurized with either dry nitrogen/air or SF6 gas until required.

TABLE-IA-I
Requirements for 420kV Current Transformer

(For Line and Bus coupler feeder)

No. of cores	Core no.	Application	Current ratio	Output Burden (VA)	Accuracy class	Min. knee point voltage V_k	Max. CT sec. wdg. Resistance (ohm)	Max. excitation current at V_k (in mA)	Remarks
5	1	BUS DIFF	3000-2000-1000/1	-	PS	3000/2000/1000	15/10/5	20 on 3000/1 tap 30 on 2000/1 tap 60 on 1000/1 tap	
	2	BUS DIFF	3000-2000-1000/1	-	PS	2000/2000/1000	15/10/5	20 on 3000/1 tap 30 on 2000/1 tap 60 on 1000/1 tap	
	3	METERING	3000-2000-1000/1	20 20 20	0.2S 0.2S 0.2S	-	-	-	
	4	BACKUP/LINE PRTN	3000-2000-1000/1	-	PS	3000 2000 1000	15/10/5	20 on 3000/1 tap 30 on 2000/1 tap 60 on 1000/1 tap	
	5	LINE PRTN	3000-2000-1000/1	-	PS	3000 2000 1000	15/10/5	20 on 3000/1 tap 30 on 2000/1 tap 60 on 1000/1 tap	

All relaying CTs shall be of accuracy class PS as per IS: 2705/IEC-61869-2/1

TABLE-IA-II
Requirements for 420kV Current Transformer
(For Transformer and Reactor feeder)

No. of cores	Core no.	Application	Current ratio	Output Burden(VA)	Accuracy class	Min. knee point voltage Vk	Max. CT sec. wdg. Resistance(ohm)	Max. excitation current at Vk(in mA)	Remarks
5	1	BUS DIFF	2000-1000/1	-	-	2000/1000	10/5	30 on 2000/1 tap 60 on 1000/1 tap	
	2	BUS DIFF	2000-1000/1	-	-	2000/1000	10/5	30 on 2000/1 tap 60 on 1000/1 tap	
	3	METERING	2000-1000-500/-	20 20 20	0.2S 0.2S 0.2S	-	-	-	
	4	TRANS/Reactor BACKUP	2000-1000-500/1	-	-	2000 1000 500	10/5/2.5	30 on 2000/1 tap 60 on 1000/1 tap 120 on 500/1 tap	
	5	TRANS/Reactor DIFF	2000-1000-500/1	-	-	2000 1000 500	10/5/2.5	30 on 2000/1 tap 60 on 1000/1 tap 120 on 500/1 tap	

All relaying CTs shall be of accuracy class PS as per IS: 2705/IEC 61869-2/1

TABLE-IB
Requirements for 245kV Current Transformer

No. of cores	Core no.	Application	Current ratio	Output Burden(VA)	Accuracy class	Min. knee point voltage V _k	Max. CT sec. wdg. Resistance(ohm)	Max. excitation current at V _k (in mA)	Remarks
5	1	BUS DIFF CHECK	1600-800/1	-	-	1600/800	8/4	25 on 1600/1 tap 50 on 800/1 tap	
	2	BUS DIFF MAIN	1600-800/1	-	-	1600/800	8/4	25 on 1600/1 tap 50 on 800/1 tap	
	3	METERING	1600-800/1	20	0.2S	-	-	-	
	4	TRANS BACKUP/ LINE PRTN	1600-800/1	-	-	1600/800	8/4	25 on 1600/1 tap 50 on 800/1 tap	
	5	TRANS DIFF /LINE PRTN	1600-800/1	-	-	1600/800	8/4	25 on 1600/1 tap 50 on 800/1 tap	

All relaying CTs shall be of accuracy class PS as per IS: 2705/IEC 61869-2/1

TABLE-IIA
Requirements of Voltage Transformer

Sl. No.	Particulars	400kV			220kV		
1	Rated primary voltage	420/ $\sqrt{3}$ kV			245/ $\sqrt{3}$ kV		
2	Type	Electro magnetic, or single phase capacitor VT			Electro magnetic		
3	No. of secondaries	3			3		
4	Rated voltage factor	1.2 continuous 1.5 – 30 seconds			1.2 continuous 1.5 – 30 seconds		
5	Phase angle error	± 20 minutes			± 20 minutes		
		Sec I	Sec II	Sec III	Sec I	Sec II	Sec III
6	Rated voltage (V)	110/ $\sqrt{3}$	110/ $\sqrt{3}$	110/ $\sqrt{3}$	110/ $\sqrt{3}$	110/ $\sqrt{3}$	110/ $\sqrt{3}$
7	Application	Protection	Protection	Metering	Protection	Protection	Metering
8	Accuracy	3P	3P	0.2	3P	3P	0.2
9	Output burden (VA) (Minimum)	50	50	50	50	50	50

TESTING & MAINTENANCE EQUIPMENT

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

1. SF6 Gas leakage detector.

The detector shall be portable, battery operated, hand held type and having a minimum SF6 gas leakage sensitivity of 5gm/year. The 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.

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

- ☐ (The plant necessary for filling and evacuating the SF6 gas in the switchgear shall be supplied to enable any maintenance work to be carried out. This shall include all the necessary gas cylinders for temporarily storing the evacuated SF6 gas. The capacity of the temporary storage facilities shall at least be sufficient for storing the maximum quantity of gas that could be removed from at least one phase of one complete bay (switchgear and associated equipment).
- ☐ s 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.
- ☐ o The minimum capacity parameters of evacuation plant will be as under:
 - Oil Free Suction (Recovery) Pump: 30 M³/Hour
 - Compressor (Two Stages): 15 M³/Hour
 - Oil Free Vacuum Pump: 100 M³/Hour
- ☐ H 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

Online Partial Discharge Monitoring System (Applicable for 400kV GIS substation –Both on 400kV side & 220kV side)

□□GIS equipment shall be designed so as to minimize partial discharge or other electrical discharge. A state-of-the art Partial Discharge Monitoring system shall be provided to monitor the entire GIS installation.

□□An on-line continuous Partial Discharge Monitoring (PDM) system shall be designed to

provide an automatic facility for the simultaneous collection of PD data at multiple points on the GIS & its associated GIB ducts and Voltage Transformers adopting UHF technique. The data stored shall provide a historical record of the progress of PD sources and shall identify the areas of maximum activity.

□□On-line continuous Partial Discharge Monitoring (PDM) system shall be capable for measuring PD in charged GIS environment as EHV which shall have bandwidth in order of 100 MHz–2GHz with possibility to select a wide range of intermediate bandwidths for best measurement results. The principle of operation shall be based on UHF principle of detection.

□□The scope shall cover Engineering, supply, installation, testing and commissioning of

partial discharge continuous monitoring system, with all necessary auxiliaries and accessories to make a complete system as per technical specification, including site demonstration of successful operation. Any items/accessories necessary to make the system fully functional for the trouble free online PD monitoring of complete GIS installation shall be considered as included in the scope.

The PDM system shall be provided with all its hardware and software, with readily interfacing to the UHF PD couplers installed in the GIS of present bays and future bays as shown in SLD plus 20% additional as extra. Details of this shall be submitted during engineering stage for approval.

The integration of UHF PD coupler in future GIS bays shall be done in respective package. The number of UHF PD coupler for future bays shall be decided based on GIS layout finalized under present scope (considering present GIS equipment with future provision).

The PD Monitoring PC Work Station shall be housed in a lockable cabinet with duplicate keys and shall be located in the control room of the GIS substation. Workstation PCs shall be pre-loaded with all necessary Hardware & Software. The PCs shall have each Combo drive & Retrievable disk drive (1 TB), Ethernet port 100Mbps, printer. The workstation PC shall be powered by suitable dedicated UPS and same is included in the present scope.

□□Design of on-line PDM System

1. The technical proposal for PDM system along with detailed design documentation shall be submitted for EMPLOYER'S approval during engineering stage.
2. To guarantee that sufficient coverage is available for complete GIS installation to monitor PD activity all design details shall be submitted as part of the above for review.

3. The sensitivity of the offered system shall be in accordance with CIGRE Document No. 654 that will be verified as part of site sensitivity tests.
4. UHF attenuation data of GIS shall be submitted for the switching devices, spacers, bends etc.
5. The signal attenuation level of co-axial cable per meter length and justification for the length of cable connection between the couplers and detector units shall be furnished.
6. The overall sensitivity of PD detection system shall take into account the spacing between couplers and the associated cabling, filters, amplifiers, etc.
7. The Sub-station GIS layout as a separate drawing indicating position of spacers, spread over of PD sensors with distance, sensor identification, the detector unit identification etc. shall be submitted during engineering stage for approval.
8. The PD sensors shall be identified / coordinated with the corresponding detector unit etc. with proper identification labeling and indicated in the substation PDM SLD.
9. Internal arrangement/wiring diagram is to be submitted for detector units/control cabinet etc. All internal items are to be identified / labeled to facilitate troubleshooting.
10. Supply requirement (AC & DC) to be specified for the complete monitoring system.
11. Power supply to PDM PC shall have protection against surges, overload and short circuit. A dedicated on-line UPS system shall also be provided as a backup during supply interruption, to ensure trouble-free & reliable running of the PDM System for a minimum of 15 minutes duration. Ratings of UPS shall be proposed for the approval of EMPLOYER'S. The UPS shall have enough capacity to initiate a 'safe' shut down of the PDM PC and the peripherals after this 15-minute period if normal supply fails to resume. The PDM PCs shall restart automatically on resumption of normal supply. The UPS shall not generate spikes during changeover of supply. UPS shall automatically give indication / alarm when it requires battery replacement.
Potential Free Contacts shall be generated to signal these events. These contacts shall be wired out to Annunciation / Monitoring systems. Alternately, inverter of suitable capacity is also acceptable. Critical Process and Status alarms of the PDM system shall be displayed.
12. PDM System shall be provided with a user security for accessing the system with a log-on and password entry procedure. The user levels shall be defined as a Master User and other users for the modification of system, update, and entry of parameters or manual operation. System shall be able to generate 3D point on wave pattern whenever any PD activity detected by the system. System shall be able to give online 3D point on wave pattern, online PRPD (phase resolved PD) and online short time trend etc. System shall be able to generate the all the logs related to system fault, system access, PD event, and any changes in system setting etc.
13. Method of electrical isolation/protection provided between PD sensor and detector circuitry in case of flashover/high potential stress inside GIS should be furnished.
14. The selected mode of propagation of PD signal (electromagnetic wave) inside GIS for the design of sensors shall be furnished.

15. The protection available for electronics against transient over voltages caused by switching operations shall be furnished.
16. The capacity of each detector unit to be specified to accommodate as many numbers of PD sensors signal.
17. The applicable standards to meet IEC & IEEE requirements for electromagnetic compatibility shall be specified. The offered system should have been tested for the same for working in a 400kV & above substation environment. The necessary documentation has to be submitted in this regard.
18. Guaranteed technical particulars & data sheet for various components used in the system shall be submitted.

□□**Calibration:** The UHF Couplers have to be first calibrated as per CIGRE procedure TF

15/330305 as part of factory acceptance tests to guarantee detection sensitivity of 5pC or better. The GIS of same design shall be used as test specimen during the coupler calibration. The pulse injection level determined through above factory calibration tests shall only be used as reference for site sensitivity checks during commissioning of PDM system. The data sheet/frequency response characteristics shall be submitted for reference.

□□**Every Day Use & Maintenance :** The system shall be designed suitable for an unmanned s/s and operate automatically. The system shall generate alarms if suspected partial discharge activity is noticed or the system itself is in failure, thereby eliminating the necessity of periodic system access by the user and one such alarm shall be connected to Substation automation system (SAS). The alarms shall be configured coupler wise.

□□**Computers and Peripherals:** The PC operating system shall be the latest version of MS Windows. It should be suitable for continuous process application and should have been tested for the same. The hardware configuration of PC should be the latest available in the market of industrial type subject to EMPLOYER'S / Engineer approval. For storing the historical PD database, sufficient storage facility in the form of hard disc and retrievable hard disk drive of 1TB as specified shall be available in the substation. The PC monitor shall be 21" LCD type of reputed make.

□□**Filtering Facility:** The filtering facility has to be provided in order to distinguish real PD from internal/external noise such as switching operations, self-test signal, radio, communication signal etc. The PDM system itself shall be able to discriminate the noise

from real PD. The exposed gas barriers of the GIS shall be shielded effectively against noise interference & tested. The gas barrier shields/belts shall be suitable for outdoor use also & able to withstand high ambient temperature. Site measurements have to be performed after installation of the PDM system in order to identify the various sources of external noise to incorporate the same in the filtering facility. This filtering will preferably be through software by band pass, which can be manually activated (as an option) to filter out noise signals in the trend plot display. If hardware filtering is

employed then adequate measures have to be taken to avoid masking of other signals, which may lie in the same frequency range. The method adopted for the above shall be specified taking into account the sensitivity requirement of PDM system as per CIGRE document. The noise filters shall be selectable individually coupler-wise.

□□**Self-Test (Diagnostic) Facility:** Built-in self-checking facility shall be incorporated in

the control system which will continuously verify the correct operation of the whole monitoring system with the simulated PD signal viz. checking of the sensitivity of individual detector units, response of PD sensors in addition to the checking of the system functioning. The periodicity of such self-check operation shall be specified. In case of system failure this shall trigger an alarm for communication to SAS. External check facility: Propose the arrangement/device available for externally checking the healthiness of PD sensors by pulse injection in addition to built-in monitoring facility.

□□**Detector Units:** The sensitivity of each detector unit shall be furnished. The sensitivity level of individual detector units shall be selectable depending on the site background noise level.

□□**Trend Plot:** The trend plot facility shall be available with the update period of hourly/daily/weekly/monthly/yearly. It shall be possible to view the historical trends for the complete archived data accumulated over several years.

□□**PD Monitoring modes:** There shall be two different modes of system operation viz. a dedicated Continuous PD Monitoring mode for the normal day today operation of the system & a dedicated HV commissioning test mode which is exclusively for PD monitoring during HV commissioning test. The HV commissioning mode shall also operate as an independent feature.

In the HV Commissioning mode the real time display shall be possible for a minimum of two complete bays with associated bus bars and at with one second update period. The HV test software shall automatically record the HV voltage information along with PD so as to check PD inception & extinction voltages precisely. The complete HV & PD data recorded during HV test shall be possible to be reviewed in replay mode after the HV test.

□□**Alarm Facility:** The PDM system shall generate alarm when action is required; viz. a) PD

alarm (abnormal PD activity indicating a risk of failure) & b) PD system fail alarm to be connected to SAS.

□□**Real Time Display:** The PDM system should have the facility of Real Time display, which will give an instant indication of PD activity coupler wise, with one-second-update period. The PDM system shall be able to capture the PD data triggered by associated switching operations of CBs & isolators.

□□**Schematics:** The PDM system should have GIS schemes bay-wise incorporating PD sensor identification and location along with spacer location. The sectional view of typical bay arrangement of GIS showing active parts shall also be included as part of the PDM software.

□□**Print Option/Facility:** PDM system should have the option/facility of printing all trend plots/reports/POW patterns/displays, etc. Laser Colour printer shall be provided for this purpose at substation.

□□**Data Archives:** This is to provide access to historical data and file storage with date and time stamp. Sufficient storage facility shall be available to review historical data updated for the lifetime of switchgear. The substation & headquarters PCs shall have a backup device in the form of a retrievable disk drive of 1TB capacity for this purpose.

□□**PD Fault Identification & Location/Pattern Recognition/Predictive Maintenance**

Diagnostic Software: In order to interpret various types of PD defects, intelligent diagnostics software (expert system) shall be built- in as part of the PDM software capability. This is mainly to reduce the dependence on PD specialist. The bidder shall also make available typical point-on-wave patterns as library pictures to train the user.

Software Updates: It shall be possible to upgrade / update the system software throughout the lifetime of the system with the ongoing development / refinement in PD technology.

□□**Fault investigation :** In case of any indication of suspected PD activity by the on line system, further investigation has to be carried out by the contractor for the PD defect identification and location during the warranty period

□□**Special Tools / equipment, Spare Parts, software packages**

Special Tools: Special tools for cutting and crimping of coaxial cable with 'N Connectors' shall be supplied.

Spare parts: The contractor has to supply critical spares with replacement procedure for the trouble free operation of the system during its expected lifetime as part of the contract. A detailed list shall be included in the tender and also submitted for EMPLOYER'S approval during the detailed engineering stage.

Software Packages: The complete software package shall be supplied as part of a back-up facility in the form of DVD/CDs viz. Windows operating system with end user license, PDM Software including HV Test, Drivers for modems etc., software for remote access, printer etc. The list shall be submitted for reference.

Pulse generator for UHF sensor sensitivity test shall also be supplied as a standard accessory.

□□**Operation & Maintenance Manual :** A complete O&M manual covering all aspects of trouble shooting of PDM system in six sets in original shall be provided & also in CD's. For diagram references colour pictures shall be provided. A step-by-step procedure for spare parts replacement shall also be included.

□□**Factory / Site Test Formats:** The factory & site tests format to be submitted for approval. The format shall cover all possible tests to confirm healthiness of the system and to record the test values.

□□**List of References:** The bidder shall provide a reference list of PD monitoring system,

TECHNICAL SPECIFICATIONS FOR ONLINE SF6 and O2 **MONITORING & ALARM SYSTEM**

1.0 General

The online SF6 & O2 gas monitoring and alarm system shall be used for detecting hazardous SF6 gas built-up in enclosed areas such as GIS switchgear rooms, cable trenches and other rooms used to store SF6.

The gas build up in enclosed spaces can be as a result of slow gas leakage from switchgear caused by damage or corrosion of switchgear seals or pressure housings, in service, or during maintenance, leakage of gas filling valves or due to emergency venting of gas due to internal pressure rise in the equipment during a fault.

It shall be suitable for indoor EHV switchgear rooms.

Pure SF6 gas is colourless, odourless, non-flammable, inert gas. At room temperature the density is more than five times that of air.

In switchgear, SF6 acts as both insulation and an arcing media. During arcing and partial discharge events, under the influence of high temperature and other factors, SF6 gas will be decomposed. Decomposition can produce highly toxic products, such as SF4, S2F2, SOF2, HF, SO2, etc. if these are inhaled, they can cause pulmonary oedema and dizziness, coma and even death.

In the relatively closed interior of a switch room, due to poor air circulation, SF6 decomposition and deposition in the room can reach harmful level during emergency conditions.

When leaking SF6 gas accumulates at lower levels in a switch room or adjoining cable trenches (due to its density) caused by a major accident, it can displace enough O2 to result in local hypoxia, asphyxiation.

The principle of operation shall be based on infrared laser absorption spectroscopy detector principle.

The system components are as follows:

- (1). Host computer: Real time display of various parameter and integrated analyzer for calculation of all monitored parameters and alarms thresholds. SCADA alarm and data transmission and control of forced ventilation fans, local alarms, lights etc.
- (2). SF6 gas laser detector: Four Gas Laser Detector Unit containing the laser absorption spectroscopy module that analyses the sampled gas for analysis from up to four (4) Collector Units. The obtained data is uploaded to the host through an RS 485 connection.
- (3). Collector: Collector for sampling and associated gas particle filtration pre-treatment. These are to be installed at the LOWEST place in the monitored area. (SF6 gas sinks to low spot).

- (4). Infrared proximity switch: Entry of persons into the GIS area automatically starts the fan and voice prompts.
- (5). The Box (Cabinet) is located in the control or relay room to control the fan start and stop and provide power to each device.
- (6). Sound and light alarm devices: If SF6 or O2 set value is exceeded, an alarm sounds to alert staff.

System Installation:

Site survey

1. If possible a site survey must be carried out and any special considerations identified and marked up on user-supplied drawings. Based on this, it should be possible to select the installation locations for sensors and the other parts.
2. The collector must be placed in sets of four (4) units so that they can connect to their allocated Four Gas Laser Detector Unit.
3. The Host Controller should be placed in an area where there is access to input power, output telecommunication lines, fan control and alarm lines.

System features:

1. Real-time display functions of various parameters.
2. Environmental SF6 gas content detection.
3. Environmental O2 content detection.
4. Environmental temperature and humidity detection.
5. Alarm when SF6 gas content exceeded allowable threshold.
6. Hypoxia alarm (i.e. Low O2 level).
7. Temperature exceeded alarm and start conditioning function.
8. Excessive humidity alarm and control of the dehumidifier function.
9. Excessive levels of hypoxial or SF6,
10. Control of exhaust air ventilation function.
11. Log query capabilities.
12. Voice prompts.
13. Sound and light alarm.
14. Last exhaust display.
15. Intelligent screen saver function.
16. Remote data transmission capabilities.

Technical Parameters:

- SF6 gas concentration alarm: $0 \sim 2000 \times 10^{-6} (v/v)$
- SF6 gas detection sensitivity: $\pm 2\%$ (laser type)
- $\pm 5\%$ set value (electrochemical transmitters)
- Detect oxygen concentration: $0 \sim 25U\%$ (with digital display)
- Oxygen concentration alarm threshold: Adjustable

- Oxygen measurement accuracy: <0.5%(0.4%, O₂ when 21%)
- Temperature display range : -25~99° C
- Temperature measurement accuracy : <0.5%
- Temperature alarm thresholds: Adjustable
- Humidity display range : 0~99% RH
- Humidity measurement accuracy: <3%
- Input Voltage 176 ~ 265V AC
- Alarm output points: 5A
- Fan output points: 5A
- Fan output contacts Power : 380V AC 40A
- Fan ventilation time setting : 15Min / second (adjustable)
- Data recording time : 2 years, the PC mass storage
- Communication: RS-485 standard protocol

Environmental operational requirements:

- Temperature: Operating temperature – 25° C -+85° C
- Humidity: less than 95% RH