**INDEPENDENT POWER TRANSMISSION OPERATOR S.A.**
**TNPRD/ SUBSTATION SPECIFICATION & EQUIPMENT SECTION**

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# TECHNICAL DESCRIPTION TD-29/14

## 170 kV $SF_6$ GAS INSULATED METAL-ENCLOSED SWITCHGEAR (GIS)

## 1. Scope of Supply

This Technical Description concerns the technical characteristics, design features and testing of 170 kV $SF_6$ Gas Insulated Switchgear (GIS) for installation indoors at IPTO 400/150/30 kV EHV or 150/20 kV HV Substation buildings. The installation of the switchgear shall be carried out in accordance with the IEC62271-203.

If the GIS is installed outdoors, then the additional requirements of Annex "A" will be applied.

## 2. Keywords

Gas Insulated Switchgear (GIS), sulphur hexafluoride ($SF_6$), Overhead Line (OHL) bay, Cable Feeder bay, Transformer Feeder (T/F) bay, Bus Coupler bay, Unit Feeder bay, Bus Section bay, VTs and High Speed Earthing Switches bay.

## 3. Operating Conditions

The GIS should be suitable for installation indoors with the following conditions:

- Ambient temperature indoors : -5 °C ÷ 40 °C
- Altitude : ≤ 1000 m
- Seismicity : As specified by the Purchaser (see paragraph 6)
- Relative humidity range : ≤ 95%
- Induced electromagnetic disturbances in secondary systems : 1,6 kV
- Corrosivity category of atmosphere, according ISO 9223 : C3

## 4. Equipment Electrical Rated Data

All 170 kV GIS equipment shall have the following rating characteristics:

| Equipment Electrical Rated characteristics | |
|---|---|
| Rated voltage | 170 kV |
| Operating voltage | 130-150 kV |
| Rated frequency | 50 Hz |
| Rated power frequency withstand voltage (1 min) | 325 kV |
| Rated lightning impulse (1,2/50 µs) withstand voltage | 750 kV |
| Permissible partial discharge intensity for cast resin at 1.2 x $U_R$ kV / √3 | < 5pC |
| Rated normal current for busbars | 2000 A, unless it is defined otherwise in the Inquiry |
| Rated normal current for feeders | 1250 A, unless it is defined otherwise in the Inquiry |
| Rated normal current for bus coupler | 2000 A, unless it is defined otherwise in the Inquiry |
| Rated short-time current | 31,5 kA |
| Rated peak withstand current | 78,75 kV peak |
| Rated duration of the short circuit | 3 s |
| Loss of gas (per year and compartment) | < 0.5% |
| Auxiliary sources of supply:<br>D.C.<br>A.C. | <br>110 V<br>230/400, 50 Hz |
| Method of earthing of the 150 kV system | Solidly earthed |

## 5. Standards

IEC62271-203 : Gas insulated metal-enclosed switchgear for rated voltages above 52 kV

| | |
|---|---|
| IEC62271-1 | : Common specifications for high-voltage switchgear and controlgear standards. |
| IEC 60376 | : Specification and acceptance of new sulphur hexafluoride. |
| IEC 60480 | : Guide to the checking of sulphur hexafluoride ($SF_6$) taken from electrical Equipment. |
| IEC62271-100 | : High voltage alternating-current circuit breakers. |
| IEC62271-101 | : Synthetic testing of high-voltage alternating current circuit breakers. |
| IEC62271-200 | : High voltage alternating current disconnectors and earthing switches. |
| IEC 61869-2 | : Current transformers. |
| IEC 61869-3 | : Voltage transformers. |
| IEC 60137 | : Insulated bushings for alternating voltages above 1000V. |
| IEC 61462 | : Composite hollow insulators for voltages greater than 1000V. |
| IEC 60099-4 | : Non-linear resistor type arresters for AC systems |
| IEC62271-209 | : Cable connections for gas-insulated metal-enclosed switchgear for rated voltages above 52 kV. |
| IEC62271-211 | : Direct connection between power transformers and gas-insulated metal-enclosed switchgear for rated voltages above 52 kV. |
| ISO 9223 | : Corrosivity of atmospheres – classification, determination, estimation |

## 6. General Requirements for GIS

The design of the metalclad switchgear shall comply with IEC Publications 62271-203, 62271-100 and 60694.

Any components or assemblies that may require replacement during the normal life of the switchgear shall be of a common design for all circuits to permit these to be interchangeable. This requirement is particularly important for the operating mechanisms of the circuit breakers, the disconnectors and the earthing switches.

The double busbar switchgear shall be designed in such a way that it is possible to remove, repair or add any circuit bay whilst maintaining one busbar in service at all times.

The GIS switchgear shall be accompanied by supporting structures. Bidders should submit drawings of the suitable supporting structures subject to Purchaser’s approval.

The switchgear and its supports shall have adequate external anticorrosive protection, suitable for the atmospheric corrosivity stated in par.3. The Manufacturer shall submit for approval to the Purchaser the protection system of each metallic part, as well as test reports or calculation proofing the adequacy of the anticorrosive protection.

The GIS switchgear shall be designed to withstand the seismic requirements of IEE 61166 with qualification level of AF5 (0,5g Horizontally). For vertical severity the direction factor (D) shall be 0,5 (as per IEC60068-3-3).Furthermore the requirements of the Inquiry shall be satisfied.

The qualification level shall be proven either by test certificates of a bay identical to the ones required by this hereby technical description or by combined test and mathematical analysis for the OHL bay of this hereby technical description.

The test certificates or the mathematical analysis must be submitted along with the technical offer. If neither is submitted, the eventual supplier shall carry out the test without any cost for IPTO S.A. For this reason, offers shall include the cost for a seismic qualification test.

## 6.1. Bushings

All the bushings for connections of the GIS switchgear with 150 kV overhead lines ($SF_6$-to-air bushings) and 150 kV cables ($SF_6$-to-cable bushings) shall generally be in accordance with IEC 60137, IEC 62271-305, IEC-62271-306 and IEC 61462 where applicable.

All air bushings whether they are intended for OHL or cables shall either be of porcelain of grey color or of silicon rubber.

Creepage distance shall be 4250 mm, unless it is defined otherwise in the Inquiry.

## 6.2. Enclosures and Conductor Expansion

Busbar and conductor connections and enclosures shall be designed to absorb the effects of thermal expansion and contraction and the agreed permissible movement of the foundations without impairing the guaranteed performance of the equipment.

Expansion joints of flexible connections shall be provided in the enclosures at suitable locations to directly absorb any slight movements and to ensure that the installation will not be subjected to stresses leading to early failures. In addition adjustable mountings shall be provided to accommodate reasonable tolerances with all associated civil works and any other installations to which the switchgear may be connected. The acceptable tolerances shall be stated in the Technical Data Sheets.

Equipment foundation, floor and structure fixing, to suit the switchgear design concept utilized by the manufacturer, shall be provided whereby movement can be absorbed within the switchgear expansion joints or transmitted through the enclosure and sliding supports to flexible connections.

A flexible conductor and enclosure connection shall be provided at the coupling point and shall be capable of withstanding these conditions for the life of the equipment.

## 6.3. Gas Compartments

The switchgear shall be divided into separate gas compartments by the use of gas tight barriers.

Gas section volumes shall be as large as possible to minimise the effects of any internal overpressure and shall be consistent with the need to allow changes in the switching arrangements for maintenance, repair or extension whilst ensuring that the remaining parts can remain energised.

Each gas compartment shall be provided with facilities for routine checking of gas moisture content and purity. Gas compartments shall be fitted with permanent connection points and valves for filling, emptying and gas treatment equipment without moving the switchgear.

All such valves shall have facilities for attaching two lead seals, one of which will be attached by the Owner and the other by the Contractor. This is to ensure that the gas system may only be opened in the presence of both parties. The seals will be fixed initially upon commissioning of the switchgear. Alternatively, gas valves shall be closed with a screwing cover and a permanent marker shall be used after the installation and commissioning.

Busbar enclosures shall be segregated into gas tight compartments of such volumes, so as to ensure that the amount of time necessary for discharging the $SF_6$, subsequent vacuum treatment and refilling does not exceed the time stated in the Technical Data Sheets.

Where compartments are interconnected through external gas pipes, these pipes shall be provided with vacuum couplings, wherever compartments are interconnected through external gas pipes, to prevent the escape of gas during testing or maintenance.

Each gas compartment shall include the following:

- A pressure relief device to guard against excessive overpressure.
- An absorber to take up residual moisture.
- A density switch functioning as a temperature-compensated pressure monitor with a two level alarm.

### 6.4. Gas Filters

Each gas compartment shall be fitted with gas filters, driers or desiccants for the absorption of the moisture and the gaseous products of switching. It shall be possible to replace the active materials of the filter without extensive dismantling.

### 6.5. Gas Barrier and Supporting Insulators

All internal support insulators and gas barriers shall be of a high quality material designed to minimise internal and surface electrical stresses. The materials shall be free of voids and partial discharges at the maximum working voltages.

Gas barriers shall be gas tight and of sufficient strength to withstand short circuit forces and the maximum pressure difference that can occur under internal fault conditions.

### 6.6. Gas Seals

All stationary and moving gas seals shall be designed to prevent gas leakages and moisture ingress under all normal conditions of service. The materials used for gas seals shall withstand exposure to $SF_6$ gas and its decomposition products without deterioration for the service life of the equipment.

Measures shall be incorporated to eliminate any deterioration of gas sealing surface edges and joinings due to the influence of climatic conditions.

Seals between different insulating media, sliding or rotating surfaces and those exposed to the risk of deterioration, due to their use outdoors, shall preferably include multiple seals. Details of the materials used and methods of sealing shall be stated in the Technical Data Sheets.

### 6.7. $SF_6$ Gas Requirements

All $SF_6$ gas supplied for use in the switchgear shall comply with the detailed requirements of IEC 62271-303 and IEC 60480, which are the minimum standards acceptable.

The gas system of the switchgear shall utilise low pressures to minimise leakages and eliminate any possibility of liquefaction at the lowest ambient temperatures. The equipment shall be designed in a way that no heating elements will be required for satisfactory operation within the range of ambient temperatures and pressures encountered under service conditions.

The minimum dew point temperatures in unheated $SF_6$ gas filled equipment shall not exceed -20$^{o}$C at the working pressure.

### 6.8. Gas Monitoring

A SF6 gas sensor shall be installed on each independent gas tight compartment providing analog or digital continuous temperature compensated indication for gas density and temperature. The measuring temperature range shall be -40÷+70$^{0}$C and the measuring range shall be 0÷900kPa absolute at 20$^{0}$C and 0÷60kg SF6/m$^{3}$ or otherwise adjusted to the specific design requirements of the GIS equipment. Typical accuracy of the density sensor shall be ±1% FS at 20$^{0}$C. The sensor output shall be integrated to the DCS and the Gas Monitoring Systems of the substation.
Additionally a dew point and temperature sensor shall be installed for on-line monitoring of SF6 dew point. Measurement range of the dew point sensor must be appropriate for the GIS system installed with a typical accuracy of ±3$^{o}$C. The analogue or digital output of the sensor shall be also integrated to the DCS and GMS systems of the substation.
It is permitted to use sensors that combine both density and dew point measurement with individual characteristics compatible with the ones described above.

Alternatively to a dew point sensor, a calculated value of dew point based on gas pressure and temperature could be accepted as long as the accuracy of a sensor is guaranteed.
The DCS and Gas Monitoring Systems shall be able to visualize the aforementioned signals and shall be configurable in order to allow the setting of alarm thresholds based on absolute limits and rate-of-change patterns.

## 6.9. Enclosures

The enclosures for the $SF_6$ gas insulated switchgear shall be either of aluminium alloy painted in the outside or of welded steel painted inside and outside and shall be designed to minimise losses and heating due to circulating currents.

Dimensioning of enclosure wall thickness and type of material shall be such as to safely withstand over-pressures caused by internal faults corresponding to maximum fault levels for a minimum time of 500 milliseconds then the arcing shall be contained for the longer time necessary for protection operation.

Bursting discs or equivalent shall be provided where necessary to protect the main enclosure from uncontrolled discharge of arced gases due to burn through of the enclosure or mechanical failure.

Bursting discs shall be directed away from personnel operating zones by suitable vents also designed to prevent accidental damage to discs.

Evidence shall be provided to verify that enclosures have been designed and tested in accordance with established pressure vessel codes without encroaching on internationally agreed safety factors for this type of equipment.

Each enclosure shall include facility for easy access to the circuit breaker, disconnector and earth switch contacts for inspection and repair and removal.

Each enclosure shall be provided with lifting points to facilitate maintenance or repair work.

The enclosures shall be connected to earth (effectively earthed). All metal parts which do not belong to a main or an auxiliary circuit shall be earthed.

## 6.10. Position Indicators

Position indicators shall be provided for all circuit breakers, disconnectors and earthing switches to show whether the main contacts of these switches are in the fully open or closed positions.

Indicators shall be of a reliable mechanical design and shall be positively driven in both directions by the final drive stage of the contact operating mechanism. Each indicator shall be clearly visible to operating staff at operating control points and access routes provided under this contract.

Additionally inspection windows capable of withstanding internal faults and external damages shall be foreseen for visual checking of the contact positions of all three phases of each particular item.

### 6.11. Pressure relief devices

Pressure relief devices shall be arranged so as to minimize the danger to an operator during the time that work is performed in the gas-insulated substation if gases or vapours are escaping under pressure.

### 6.12. Interconnecting components

The various components of the GIS shall be assembled together by means of standardized bolted flanges.

Telescopic coupling elements, e.g. in busbars, shall be used to connect adjacent switchgear sections. Expansion elements with metal bellows shall be used where necessary to compensate for thermal expansion or contraction cycles.

### 6.13. Labelling and equipment information to limit $SF_6$ greenhouse gas emissions

Based on regulation (EU) No 517/2014 of the European Parliament and of the Council on fluorinated greenhouse gases, the manufacturer must provide the following information, as required in the contract terms:

1. a reference that the equipment contains $SF_6$ greenhouse gas or that its functioning relies upon $SF_6$ greenhouse gas
2. the accepted industry designation
3. the quantity expressed in weight (kg) and in $CO_2$ equivalent (kt $CO_2$ – eq), contained in each GIS equipment unit, and the global warming potential (GWP) of $SF_6$ greenhouse gas

## 7. Basic components of a typical GIS bay

### 7.1. Circuit Breakers

7.1.1 General

1. Two types of Circuit breakers may be used, according the type of GIS bays included in the Inquiry.
   a. Circuit breakers suitable for single pole operation, for the following types of GIS bays:
      - 150 kV Submarine Cable Feeder (controlled/synchronized closing)
      - 150 kV Busbar Reactor Feeder (controlled/synchronized opening)
      - 150 kV Line Reactor Feeder (controlled/synchronized opening)
      - 150 kV Capacitor Feeder (controlled/synchronized closing)
   b. Circuit breakers suitable for three-pole operation for the following types of GIS bays:
      - 150 kV Overhead Transmission Line Feeder
      - 150 kV Bus Coupler bay

- 150 kV Bus Section bay
- 150 kV/MV Transformer Feeder
- 400/150/30 kV Autotransformer feeder bay
- 150 kV Power Plant feeder bay

2. Circuit breakers shall be of the puffer type or auto puffer type or self-compression type (self blast) with operating mechanism of either spring type or hydraulic type.

   Unless otherwise specified herein, all material, equipment, manufacturing and testing of the subject circuit breakers shall conform to the latest revision of IEC 62271-100 standard.

3. Each circuit breaker shall be capable of making and breaking short circuit faults in accordance with the quantities, factors and service operation, requirements specified and in addition to fulfil all the requirements specified hereafter in this specification under par. 7.1.3. "*Specific Requirements for Circuit Breakers*".

4. All equipment entering into the breakers shall be new, of first grade quality, as to material, workmanship and design. Material and apparatus furnished under this Specification shall be subject to inspection by the Purchaser. The Purchaser's Inspectors shall have access, during working hours, to all parts of shops where material is manufactured and shall be provided by the Seller with reasonable inspection facilities. The Purchaser's representative may at any time inspect any or all test data. Release of material shall not relieve the Seller from responsibility of furnishing material to conform to all requirements of the Purchaser's order nor invalidate any claim, which the Purchaser may make because of defective or unsatisfactory material.

5. The circuit breaker shall not be strained when making or breaking the rated short circuit currents. Under these conditions, there shall be no leakage of $SF_6$.

6. Auxiliary arcing contacts shall be provided to protect the main contact during the operation of the circuit breakers. All contacts shall be readily and quickly replaceable.

7. All seals shall be sufficiently tight to hold pressures incident to temperature changes resulting from normal operation and changes in ambient temperatures without leakage or breathing of moisture.

8. The circuit breakers and operation mechanism shall be suitable for high speed three-phase auto-reclosing (one shot).

   Operating mechanism shall be of the mechanically and electrically trip-free type.

   Electrical tripping devices shall operate between limits of 30 per cent below and 10 per cent above normal operating voltage with the coils at a temperature of 45$^{o}$C.

The circuit breaker operating mechanism shall be so designed that the circuit breaker is free open immediately when the trip coil is energized.

In case the circuit breaker consists of 3 separate single-phase units with a common operating mechanism, the units shall be coupled so that their accurate alignment is not necessary and so that any unit can readily be replaced by a spare unit. It shall be possible to make independent adjustments on each unit. The operation of the 3-single phase units shall be simultaneous.

Means shall be provided for the manual operation of all circuit breakers for maintenance purpose.

9. An approved design of handling equipment shall be provided for each type of circuit breaker.

10. In addition to the accessories specified here above, each circuit breaker shall be equipped with an operating mechanism, which shall contain the following:

    - Space heater element or elements automatically controlled by thermostat, inside the weatherproof housing of the operating mechanism.
    - Operation counter.
    - Wiring diagram mounted inside the main door of the mechanism housing.
    - Position indicator to show clearly from the vicinity of the mechanism the open and closed positions of the circuit breaker.
    - Copper grounding pads.
    - Name plate of non-corrosive material giving the Manufacturer's name, address and the apparatus type, the year of manufacture, the serial number and the main characteristics of the breakers operating mechanism.
    - Manual-emergency operation of the circuit breaker in case of DC auxiliary supply voltage loss or charging motor failure. The manual operation shall be realised by a hand crank and it shall be possible to lock the operating mechanism box after the manual operation.
    - $SF_6$ circuit breaker shall be equipped with a suitable gas monitoring device for the control of $SF_6$ gas density.
    - Local-Remote-Off control switch switch located at the Local Control Cubicle,, with as many stages as needed for the control circuits of the breaker. The “local” position and in conjunction with two (2) push-buttons or a control switch, will be used to control the circuit breaker from the LCC, for maintenance purpose only. When the circuit breaker is under local control, the circuit breaker bay will be out of service. The “remote” position shall be used to control the circuit breaker from a remote place and for tripping purposes. Furthermore, the "Local-Remote-Off" selector switch shall be equipped with an additional number of stages, to those used for all the control circuits, in order to interrupt both positive (+) and negative (-) 110V DC buses of the control circuits.

For the wiring of the above mentioned circuits, a selector switch (L-0-R), equipped with at least ten (10) pairs of contacts is required.

- For verifying the expiration of the time required for charging of the circuit breaker springs, an auxiliary time-relay (OFF-delay-ON) will be provided. The auxiliary relay will be excited by the limit switch contact that controls the charging of the springs. The auxiliary relay contacts will change position after a time (t), greater than the time required for charging the springs, giving an alarm.

- Two push-buttons for local closing and opening of breaker.
- Auxiliary contacts readily changeable to normally open or normally closed as follows :

| | |
|---|---|
| 7 free N.O. | contacts (at least) |
| 7 free N.C. | contacts (at least) |

7.1.2. Operating Duty and Performance

1. The requirements of IEC62271-100 in respect of service, operation and the making and breaking of fault currents shall apply to the specified circuit breakers.

2. Rate of Rise of Restriking Voltage: Attention is drawn to the requirements of Schedule of Tests wherein the minimum inherent rates of rise of restriking voltage of test plant arrangements are stated. Where not specifically stated in the test certificates submitted with the Inquiry, the Inquiry shall certify that the R.R.R.V. to which the circuit breaker was subjected during the short circuit tests was not less than the inherent values of the test plant stated in the Schedule of Tests for the first phase to clear factor of 1.5. Any device incorporated in a circuit breaker to limit or control the rate of restriking voltage across the circuit breaker contacts shall likewise be to the Engineer's approval and full descriptions of any such device shall be given.

3. Reclosure Duty: Circuit breakers controlling transmission lines shall be suitable for high speed auto reclosure. Circuit breakers must be capable of coping with the interrupting duties produced by out of synchronism conditions associated with auto reclosure.

4. Interrupting Duty: Circuit breakers must be capable of coping with the interrupting duties produced by the switching of transformer magnetizing currents, line charging currents, cable charging currents, capacitor banks, short-line faults and out-of-phase switching duties.

5. Fault Clearance Time: The overall fault clearance time including relay operating time shall not exceed 90 ms.

7.1.3. Specific Requirements for Circuit Breakers

1. The circuit breakers shall have one interrupting chamber per phase. All units shall be suitable for high speed three-pole auto-reclosing (one shot).

| | | |
|---|---|---|
| 2. | Rated voltage (according to IEC) | : 170 kV |
| 3. | Lightning impulse withstand voltage, positive and negative polarity, 1.2/50 μs wave, applied between phase and ground and between phases and across breaker's open contacts | : 750 kV crest |
| 4. | Rated frequency | : 50 Hz |
| 5. | Power frequency withstand Voltage, 50Hz, for 1 minute | : 325 kV rms. |
| 6. | Rated normal current | : as defined in paragr. 4, unless different requirements are defined in the inquiry or contract. |
| 7. | Rated short-circuit breaking current (at 170 kV)<br>-r.m.s. value of A.C. component,<br>-percentage of D.C. component | <br>: 31,5 kA rms.<br>: in accordance with IEC62271-100 |
| 8. | Rated transient recovery characteristics for terminal faults corresponding to 100% rated short-circuit breaking current :<br>-First-pole-to-clear factor (phase factor)<br>-Rated transient recovery voltage<br>-Rate of rise of recovery voltage | <br>: 1.5<br>: 291 kV peak<br>: 2 kV/μs |
| 9. | Rated short-circuit making current, in kA. It will be equal to 2.5 times the rms value of the A.C. component of the rated short circuit breaking current, i.e. | : 78.75kA peak |
| 10. | Rated short circuit duration (capability of breaker to carry, when closed, the rated short-circuit breaking current for the specified time period). | : 3 s |
| 11. | Rated operation cycle (the breaker shall be capable of three-phase, high speed reclosing, in accordance with the subject duty cycle, without derating) | : O-0.3 s-CO-3 min-CO |

12. <u>Interruption of shunt reactor currents</u>

    The breaker will have shunt reactor load switching capability, according to IEC 62271-110.

13. <u>Interruption of unloaded lines</u>

    The breaker shall be able to interrupt overhead line charging currents of 63 A, with class C2 (very low restrike possibility) according to IEC 62271-100.

14. Interruption of unloaded underground cables

The breaker shall be able to interrupt capacitive cable charging currents up to 160 A with class C2 (very low restrike possibility) according to IEC 62271-100.

15. Rated transient recovery characteristics for short-line faults

| | |
|---|---|
| -Rated transient recovery voltage | : 194 kV peak |
| -First pole to clear factor | : 1 |
| -RRRV | : 2 kV/μs |

16. Mechanical endurance class: M1 (2000 operations)

17. Interrupting time

The maximum interval between energisation of the tripping coil and interruption of the main circuit in all poles of the breaker must not be greater than 60ms, at 100% of the rated breaking capacity, and 70 ms at 10%, 30%, 60% of the rated breaking capacity.

18. Operating time diversion

The operating time diversion between breaker poles and between breaks of each pole, on closing or tripping shall not exceed 5 msec (shorter times will be preferred).

| | |
|---|---|
| 19. Number of tripping | : two (2) |
| 20. Number of closing coils | : one (1) |
| 21. Supply voltage of tripping and closing coils | : 110 V DC |
| 22. Tolerances of the supply voltage of the tripping coils | :-30%,+10% |
| 23. Tolerances of the supply voltage of the closing coil | :-15%,+10% |

7.1.4. General arrangement and pressure withstand

Evidence shall be provided that enclosures subject to pressures in excess of normal atmospheric pressures can withstand these pressures, without leakage, permanent distortion or any temporary distortion, such that might cause malfunction of the circuit breaker.

Means shall be provided to allow access for inspection and maintenance of fixed and moving contacts and other enclosed components.

7.1.5. CB' s operating mechanism additional requirements

All 170 kV circuit breaker operating mechanisms shall be fitted with independent duplicate shunt trip coils (2 coils) suitable for either independent or simultaneous operation.

Circuit breaker mechanisms shall be "trip free" as defined in IEC Publication 60050 (441).

Each part of the operating mechanisms shall be of substantial construction, utilising such materials as stainless steel, brass or gunmetal where necessary to prevent sticking due to rust or corrosion. The overall designs shall be such as to reduce mechanical shock due to fault current stresses, vibration or other causes.

An approved mechanically operated indicator shall be provided on each circuit breaker operating mechanism to show whether the circuit breaker is open or closed.

In case the circuit breaker is comprised of three independent units it shall be possible to make independent adjustments to each unit and or to the three units so that make and break the circuits simultaneously. In the event of any phase failing to complete a closing operation, provision shall be made for automatic tripping of all three phases of the circuit breaker (pole discrepancy). This requirement shall also be applicable and for breakers with non independent poles (3-pole CBs).

Anti-pumping relays shall be provided to prevent reclosing in case the closing coil remains energised and the circuit breaker fails to latch in the closed position or is tripped during closing.

Approved means for manual operation of the circuit breaker shall be provided.

7.1.6 Additional requirements for the CBs used in 150 kV Capacitor Bank bays and in Submarine Cable Feeder bays

The CBs used in 150 kV Capacitor Bank bays shall be capable for controlled switching (synchronized closing and opening) of 155 kV Shunt Capacitor Banks, for clearing of all types of faults and also for tripping due overvoltages and current unbalances. Also the CBs used in Submarine Cable Feeder bays shall have the same requirements, as the CBs for Capacitor bays, because they will switch long cables having capacitive charging current higher than the standard capacitive cable charging current of par.7.1.3.14. These particular CBs shall fulfill the following additional requirements :

1. The CB shall be single-pole operated. Each pole will be closed when the respective source phase-to-ground voltage is zero with the aid of a synchronous switching relay. During tripping due to faults, overvoltages and current unbalances, the breaker will operate independent of the synchronous switching relay. Tripping due to faults, overvoltages and current unbalances will be accomplished with the aid of phase+earth overcurrent, overvoltage, current unbalance and bus-bar differential relays.
   Each pole of the breaker must be equipped with an individual operating mechanism panel which shall contain, besides other things and the mechanism’s motor.
2. The restriking class of the CB shall be C2, that is with very low probability of restrike during capacitive current breaking.

3. The rated single capacitor bank breaking current shall be 400 A r.m.s.
4. The rated back-to-back capacitor bank breaking current shall be 400 A r.m.s.
5. The rated back-to-back capacitor bank inrush making current shall be 20 kA peak with 4,25 kHz frequency.
6. The rythm of decay of dielectric strength of each pole shall be greater/equal of 44 kV/ms.

7.1.7 Additional requirements for the CBs used in 150 kV Shunt Reactor bay

The CBs used in 150 kV Shunt Reactor feeder shall be capable for controlled switching (closing and opening) of 157.5 kV Shunt Reactor, for clearing of all types of faults. The CB shall be single-pole operated. Each pole will be open and closed with the aid of a synchronous switching relay. Each pole of the breaker must be equipped with an individual operating mechanism panel which shall contain, besides other things and the mechanism's motor.

**7.2. Busbars**

Double busbars shall be extendible according to the requirements of the Inquiry. The three phases of each busbar shall be placed in common or in separate compartments filled with $SF_6$. Each busbar shall be earthed through high speed earthing switch.

**7.3. Disconnectors**

Disconnectors shall comply with the requirements of IEC62271-101 and IEC62271-203.

Disconnecting switches shall be designed for live operations and will not be required to switch current other than bus charging currents.

The lightning impulse withstand voltage shall be:

- Phase to earth and between phases : 750 kV peak
- Across the isolating distance : 860 kV peak

The power frequency withstand voltage shall be:

- Phase to earth and between phases : 325 kV rms
- Across the isolating distance : 375 kV rms
- The rated current shall be : as defined in the Inquiry.
- The rated short-time withstand current shall be : 31,5 kA
- The rated peak withstand current shall be : 78,75 kA peak
- The rated duration of short circuit shall be : 3 s
- The mechanical endurance class shall be :M1 (2000 operations)

-The mechanism shall include provision for manual operation in case of an emergency.

The manual emergency operation shall be carried out via rotary motion and metallic reduction gear with a hand-handle which shall be removable. The

electric control circuit shall be placed automatically out of service when the hand-handle is inserted for the manual emergency operation. The parts of the handle which come in contact with the human hands shall be covered with insulating material. The insertion of the removable hand-handle to the housing shall be possible through an opening in the outer surface of the housing of the operating mechanism. This opening shall be capable of being secured with a padlock. The removable handle shall be kept inside the housing of the operating mechanism.
-Local-Remote-Off control switch located at the Local Control Cubicle, with as many stages as needed for the control circuits of the disconnectors and earthing switches of the bay. The “local” position and in conjunction with two (2) push-buttons or a control switch, will be used to control the disconnector, from the LCC for maintenance purpose only. The “remote” position shall be used to control the disconnector from a remote place.

Locking shall be provided for the manual hand crank, in both open and close positions, with mechanical couplings, to ensure all three phases open and close simultaneously. Means shall also be provided for emergency manual operation.

Disconnectors of a metalclad and approved type design shall be arranged to allow safe maintenance of any section of the equipment, while the rest of the equipment are energised.

The position of the disconnector’s contacts shall be indicated by a reliable indicating device.

The lightning and power frequency withstand voltages shall apply at the minimum operating density of the insulating medium.

The disconnectors shall be equipped with auxiliary contacts as follows:

- 5 voltage free N.O. contacts (at least)
- 5 voltage free N.C. contacts (at least)

### 7.4. Busbar Disconnectors

For on load changeover of busbars in stations with double busbars the disconnectors shall be interlocked so that it is not possible to parallel or disconnect two sections of busbars by means of the busbar disconnectors unless a paralleled bus-coupler circuit is already closed.

In all other circumstances, busbar disconnectors shall be interlocked so that their respective circuit breakers can only be connected to one set of busbars at a time.

The busbar disconnectors shall be equipped with auxiliary contacts as follows:

- 5 voltage free N.O. contacts (at least)
- 5 voltage free N.C. contacts (at least)

### 7.5. Low speed Earthing Switches (maintenance earthing switches)

Earthing switches without making capacity, integral with disconnectors or separately mounted, shall function in such a manner so as to provide an earthed zone, permitting access for maintenance purpose to circuit breakers, busbars, and all parts of the main circuits. Earthing switches shall be electrically operated. They will be used in conjunction with the circuit breaker, one at each side of the circuit breaker.

The earthing switch, when in the closed position, shall be capable of carrying the rated short time current (31,5 kA) for three seconds without the contacts getting burnt or melted.

Facilities integral with the earthing switch for primary current injection or low voltage checks shall be insulated from earth and incorporate a disconnectable earth strap.

The position of the earthing switch is to be indicated by a reliable indicating device.

The maintenance earthing switches shall be equipped with auxiliary contacts as follows:

- 3 voltage free N.O. contacts (at least)
- 3 voltage free N.C. contacts (at least)

### 7.6. High Speed Earthing Switches

High speed earthing switches shall be capable of sustaining for three seconds the rated short circuit current (31,5 kA) of the switchgear. They shall be used in conjunction with bus coupler (tie) disconnectors and the disconnectors of the OHL or cable feeder. They shall be used in conjunction with the OHL disconnector. Power operated mechanisms shall be self locking in both open and closed position.

High speed earthing switches shall be capable of interrupting induced currents, as may be necessary when used for grounding one out of two or more parallel circuits.

Facilities integral with the earthing switch for primary current injection or low voltage checks shall be insulated from earth and shall incorporate a disconnectable earth strap.

The position of the earthing switch is to be indicated by a reliable indicating device.

The high speed earthing switches shall be electrically operated.

The high speed earthing switches shall be equipped with auxiliary contacts as follows:

- 3 voltage free N.O. contacts (at least)
- 3 voltage free N.C. contacts (at least)

## 7.7. Earthing Switch Operating Mechanism

Earthing switch operating mechanisms shall be of robust construction, carefully fitted to ensure free action and shall be unaffected by the climatic conditions at site. Mechanisms shall be as simple as possible and comprise a minimum of bearing and wearing parts.

All power driven earth switches shall include provision for manual operation. The manual operation shall be carried out via rotary motion and metallic reduction gear with a hand-handle which shall be removable. The electric control circuit shall be placed automatically out of service when the hand-handle is inserted for the manual operation. The parts of the handle which come in contact with the human hands shall be covered with insulating material. The insertion of the removable hand-handle to the housing shall be possible through an opening in the outer surface of the housing of the operating mechanism. This opening shall be capable of being secured with a padlock. The removable handle shall be kept inside the housing of the operating mechanism.

Through the Local-Remote-Off control switch located at the LCC, the earthing switch shall be able to be operated either locally or remotely. The “local” position and in conjunction with two (2) push-buttons or a control switch, will be used to control the earthing switch, from the LCC for maintenance purpose only. The “remote” position shall be used to control the earthing switch from a remote place.

## 7.8. Current Transformers

Current transformers shall be included in the $SF_6$ switchgear for the various circuits and shall comply with IEC 61869-2.The number of current transformers, the number of secondary windings of each current transformer and the corresponding technical characteristics of its windings (e.g. ratio, burden, accuracy class, etc) will be defined in the Inquiry.

In case separate terminal boxes are used for current transformer secondary wiring, the identifying labels shall be fitted to the terminal boxes in a conspicuous position but not on removable covers.

Current transformers shall have a short time thermal primary current rating not less than that of the associated switchgear (31,5 kA). The dynamic current rating shall be 2,5x the rated short time thermal current. Secondary windings of each current transformer shall be earthed at one point only through a link and wired through the terminal blocks.

Magnetisation and core loss curves shall be provided for each type and rating of current transformer.

The power frequency voltage withstand of the secondary windings shall be 3 kV rms.

All secondary winding connections shall be brought out and connected by means of separately insulated leads to a terminal board mounted in an accessible position.

Current transformers for indication or metering shall have their secondary winding earthed at the switchgear.

Secondary windings which are not loaded must be short circuited before the transformer is energised.

The rated continuous thermal current of the current transformers shall be 1,2x rated current.

The terminal designation of the primary and secondary windings shall be in accordance with IEC 61869-2 (2011).

### 7.9. Voltage Transformers

Voltage transformers (VTs) shall comply with IEC 61869-3 and shall be included in the $SF_6$ switchgear. The number of voltage transformers, the number of secondary windings of each voltage transformer and the corresponding technical characteristics of its windings (e.g. ratio, burden, accuracy class, etc) will be defined in the Inquiry.

Voltage transformer secondary windings shall be earthed at the switchgear through a link, which can be removed for insulation testing.

The rated voltage factors of the VTs shall be : 1,2 continuous

1,5 for 30 sec

The power frequency withstand voltage of secondary windings shall be: 3 kV rms

A label shall be provided at the secondary terminal boards (boxes) clearly indicating the connection required for each winding and/or ratio.

All secondary terminals shall be suitable to be wired with 4mm² size conductors. Furthermore, all secondary phase leads shall be protected by appropriate explosion type fuses and the neutral leads by links.

The VT compartment shall be able to be disconnected/isolated for maintenance reasons.

### 7.10. Surge arresters

If GIS surge arresters are requested by the Inquiry to be installed in the GIS, these arresters shall have the following characteristics:

The surge arresters shall be in accordance with IEC 60094-4, second edition:

a. Continuous Operating voltage, $U_c$ : $108 \leq Uc \leq 116$ kV rms

b. Rated voltage as defined in IEC60094-4, $U_r$ : 144 kV rms

c. Nominal discharge current $I_n$ (8/20μs) : 10 kA, peak

d. High current impulse withstand : 100 kA, peak

e. Rated short circuit current $I_s$ : 31.5 kA rms

f. Classification

- Class : Station
- Duty : Medium
- Designation : SM
- Thermal energy rating $W_{th}$ : ≥ 7 kJ/kV
- Repetitive charge transfer rating $Q_{rs}$ : ≥ 1.6 C

g. Residual voltage at 1 kA switching current impulse (>30/60 µs) (switching impulse protection level, SIPL) : ≤ 299 kV, peak

h. Residual voltage at 10 kA lighting current impulse (8/20 µs) (lightning impulse protection level, LIPL) : ≤ 382 kV, peak

The surge arresters shall be equipped with a monitoring device, which will register each current surge with time tag, count the current surges and measure the resistive leakage current of the arrester. It will be suitably configured to register also switching current surges. The time tagged switching current events will be transmitted to the Substation Automation System. All necessary devices to realize this will be provided by the Contractor.

### 7.11. Interlocking Facilities

Disconnecting devices, earthing switches, circuit breakers, etc. shall be provided with an interlocking system, which ensures safe operation of the equipment under all service conditions.

Wherever mechanical interlocks are employed, they shall be effective at the point where handpower is applied, so that stresses cannot be transferred to parts remote from that point.

Auxiliary control switches, used in the electrical interlocking schemes, shall be arranged to ensure that the associated switching device is either in the fully open or fully closed position (as appropriate), before the interlocking circuit is completed.

Circuit breakers shall be interlocked so that it is not possible to close a circuit breaker unless its associated disconnector or disconnectors is/are closed, with the exception of maintenance situations.

Disconnecting switches shall be interlocked so that they cannot be operated unless the associated circuit breaker is open, except during on load transfer of feeder circuits from one busbar to another. In this case, the Bus Coupler bay disconnectors can be closed, providing the Bus Coupler bay breaker is closed and the disconnector of the other busbar is also closed.

Earthing switches shall be interlocked so as they cannot be operated unless their associated disconnecting switches are open.

### 7.12. Padlocks

Padlocking facilities shall be provided for disconnectors and high speed earthing switches on their operating mechanism boxes.

Locks shall be designed, constructed and located on the equipment so that they will remain serviceable in the climatic conditions specified without operation or maintenance.

### 7.13. Operating mechanisms Cubicles and other electrical accessories

Circuit breakers, disconnectors and earthing switches operating mechanisms, which contain auxiliary control switches and associated relays, control cable terminal blocks, and other auxiliary equipment shall be accommodated in sheet steel vermin proof cubicles. The cubicles shall be free-standing, with front access, and shall be equipped with anti-condensation heaters controlled by thermostat and interior lighting.

Cubicles shall be of rigid construction. Access to all compartments shall be provided by either removable panels or doors. All fastening shall be integral with the panel or door and locking shall be made available. Doors and panels shall be fitted with weatherproof sealing material, suitable for the climatic conditions specified. Cubicles shall be well ventilated through vermin-proof louvers. Enclosure classification shall be a minimum of IP42 as per IEC 60529.

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 the associated apparatus.

Other electrical accessories installed on the GIS (e.g. SF6 density switches, etc) shall also have classification at least IP42 as per IEC 60529.

### 7.14. Control and Indications

The GIS switchgear shall be capable of being controlled from the following positions:

- From operating mechanisms cubicles located nearby the equipment such as CB, D/S and E/S and with indications and mimic diagrams.

- From the HMI centre located in the substation control room. Control of circuit breakers, disconnectors and earthing switches with position indication in each instance.

- Remote IPTO’s transmission dispatching centre. Control of circuit breakers and disconnectors and position of earthing switches.

- Remote IPTO's distribution dispatching centre, (if applicable). Control of 150/20 kV transformers and 20 kV equipment.

### 7.15. Auxiliary Switches and Contactors

Circuit breakers, disconnectors, earthing switches and circuit selector disconnectors shall be provided with suitably rated auxiliary switches and contactors, where necessary, to relay circuit information for the purpose of control and circuit supervision at the substation control room and for protection, indication and metering, as required. In addition, two normally open and two normally closed auxiliary switches of the same type and rating, as those specified above, shall be provided as spare items on each equipment.

### 7.16. $SF_6$–to-cable bushings

The $SF_6$–to-cable bushings shall be suitable for vertical or horizontal or under angle connection to single-phase 150 kV cables. Bushings shall generally be in accordance with IEC 60137, where applicable. The connection of the terminations with the bays shall be designed in such way so that if a malfunction of a 150 kV cable/termination occurs, it won't create any other problems to the neighboring terminations (sealing-ends) or cables. All the necessary equipment for the connection of the 150 kV cables to the GIS bay must be part of the supply. The remaining technical data of the cables will be given in the Inquiry.

$SF_6$–to-cable bushings of type "plug-in" should be in accordance with IEC 62271-209.

### 7.17. $SF_6$ -to-air bushings

Outdoor bushings for connections to external conductors shall be provided where needed. Bushings shall be in accordance with IEC 60137 where applicable.

Creepage distances for the insulators of outdoor bushings fitted to the $SF_6$ switchgear and for insulators for other external equipment shall be at least 4250 mm, unless it is defined otherwise in the Inquiry.

Outdoor bushings must be capable of withstanding cantilever pull due to the external connection. Factors of safety of 2,5 minimum shall be applied.

## 8. Types of GIS bays

Each Substation of the Inquiry shall be made up by a different combination of GIS bays. Types of GIS bays commonly used in Substations are :

- 150 kV Overhead Transmission line feeder bay

- 150 kV Cable feeder bay without adjusted reactors

- 150 kV Cable feeder bay with adjusted reactors

- 150 kV/MV Transformer feeder bay

- 400/150/30 kV Autotransformer feeder bay

- Power Plant Unit feeder bay

- Bus Coupler bay

- Bus Section bay

- 150 kV Reactor feeder bay

- 150 kV Capacitor feeder bay

- SVC feeder bay

The types and numbers of the components (as described in paragraph 7) included in each bay, as well as the structure of each bay shall be given in the Inquiry or Contract.

## 9. Tests

### 9.1. Type tests

The following type tests shall be carried out on a complete single-pole or three pole functional unit of a switchgear bay (including at least the Circuit Breaker, the Disconnectors and the Earthing Switches) :

a) Tests to verify the insulation level of the equipment and dielectric tests on auxiliary circuits.

b) Tests to prove the radio interference voltage (RIV) lever (if applicable)

c) Tests to prove the temperature rise of any part of the equipment and measurement of the resistance of the main circuit

d) Tests to prove the ability of the main and earthing circuits to carry the rated peak and the rated short-time withstand current

e) Tests to verify the making and breaking capacity of the included switching devices

f) Tests to prove the satisfactory operation of the included switching devices

g) Tests to prove the strength of enclosures

h) Verification of the degree of the enclosure

i) Gas tightness tests

j) Electromagnetic compatibility tests (EMC) (If applicable)

k) Additional tests on auxiliary and control circuits

l) Tests on partitions

m) Testes to prove the satisfactory operation at limit temperatures

n) Tests to prove performance under thermal cycling and gas tightness on insulators

o) Corrosion test on earthing connections (if applicable)

Especially for the GIS bays feeding 150 kV Capacitor banks will carried out also the following tests :
Capacitive current switching test (single or back-to-back)
Three-phase capacitor bank switching tests for class C2 duty

Concerning the VTs of an OHL switchgear bay, the following type tests shall be carried out in accordance with IEC 61869-3 standard:

1. Temperature rise test
2. Short – circuit withstand capability test
3. Radio interference voltage measurement
4. Determination of errors.

Concerning the CTs of an OHL switchgear bay, the following type tests shall be carried out in accordance with IEC 61869-2 standard:

1. Short – time current tests
2. Temperature rise test
3. Determination of errors

Type test certificates for all type tests of this hereby technical description for a complete bay can be accepted instead of actual testing. For this reason, test certificates can be submitted along with the technical offer. If the submitted type tests certificates are found not to be satisfactory, or test certificates are not submitted then the eventual supplier shall carry out these tests without any cost for IPTO S.A.

Special Tests

The following dielectric tests will be performed on a typical GIS bay (CB,DS,ES,HSES), which will be part of the delivery, on the presence of IPTO's inspector, only if the corresponding type test certificates are not accepted by IPTO or are older than fifteen (15) years from the tender date. . For test certificates up to 15 years old, the manufacturer should establish that changes made either on construction or installation, during this period, do not influence the result of the corresponding test.

- Lightning impulse test (dry) with both polarities, according to IEC 60060-1. The tests will be performed on a full bay of typical composition, for open and close position.

- Dielectric tests across open switching devices, following the preferred method. The tests will be performed on a full bay of typical composition for open and close position.

The following tests will be performed on a sample of each partition or internal support insulator, only if the corresponding type test certificates are older than eight (8) years from the tender date or not existing. For test certificates up to 8 years old, the manufacturer should establish that changes made either on construction or installation, during this period, do not influence the result of the corresponding test.

- Thermal cycle test, according to cl.6.106.2 of IEC 62271-203:2011
- Tightness test (only for partitions)

### 9.2. Routine tests

For routine tests new $SF_6$ in accordance with IEC60376, or used $SF_6$ in accordance with IEC60480, can be used.

The routine tests shall be performed on all components of a substation. Depending on the nature of tests, some tests may be performed on components, transport units or on the complete installation. The routine tests ensure that the product is in accordance with the equipment on which the type test haw been carried out.

On a complete single-pole or three pole functional unit of an OHL switchgear bay (including at least the Circuit Breaker, the Disconnectors and the Earthing Switches), the following routine tests shall be carried out:

a) Dielectric test on the main circuit
b) Tests on auxiliary and control circuits
c) Measurement of the resistance of the main circuit
d) Tightness test
e) Design and visual checks
f) Pressure tests of enclosures
g) Mechanical operation tests
h) Tests on auxiliary circuits, equipment and interlocks in the control mechanism
i) Pressure test on partitions

The tightness test on the complete GIS bay, including all available gas compartments (e.g, VTs, surge arresters, etc), shall be performed according to the cumulative method, following IEC 60068-2-17, Qm test, method 1. For the other components or transport units, the test will be performed according to the probe method, following IEC 60068-2-17, Qm test, method 2. The tightness coordination chart (TC chart), including leakage rate and time between replenishments, will be prepared by the manufacturer and submitted to IPTO’s inspector.

On the VTs of an OHL switchgear bay, the following routine tests shall be carried out in accordance with IEC -61869-3 standard:

1. Verification of terminal markings
2. Power – frequency withstand tests on primary winding
3. Partial discharge measurement
4. Power – frequency withstand test on secondary winding
5. Power – frequency withstand tests between sections of secondary winding.

6. Determination of errors.

On the CTs of an OHL switchgear bay, the following routine tests shall be carried out in accordance with IEC 61869-2 standard:

1. Verification of terminal markings
2. Power-frequency withstand test on primary winding
3. Partial discharge measurement
4. Power-frequency withstand test on secondary windings
5. Power- frequency withstand tests between sections of primary and secondary windings
6. Inter-turn overvoltage test
7. Determination of errors (This test shall be performed after the previous six tests)

Tests at site

After installation, and before being put into service, the GIS shall be tested in order to check the correct operation and the dielectric integrity of the equipment, according IEC 62271-203 par. 10.2.

These tests and verifications comprise

- dielectric tests on the main circuits after the final and complete installation of the whole GIS system, according IEC 62271-203 par. 10.2.101, PROCEDURE A. Simultaneously, partial discharge measurements will be carried out. Values of test voltages and partial discharge measurements should be in accordance with Table 6 and 7 of the above Standard,
- dielectric tests on auxiliary circuits and control circuits,
- measurement of the resistance of the main circuit,
- Check for good performance and operation for all the CBs, Disconnectors, Earthing switches etc, with measurement of the response time.
- Check for SF6 leakage. The method and the measuring instruments used should be suitable for detection of a percentage of leakage at least equal to the guaranteed value per year (as it is determined at the “Special Terms” of the Contract).

To ensure minimum disturbance, and to reduce the risk of moisture and dust entering enclosures and thus preventing correct operation of the switchgear, no obligatory periodic inspections or pressure tests concerning the enclosures are specified or recommended when the gas-insulated substation is in service. Reference shall be made in any case, to the manufacturer’s instruction book.

## 10. Nameplates and Markings

The GIS and all its operating devices shall bear legible and easily accessible nameplates which shall contain at least the following data (according to IEC 62271-203):

- Name of manufacturer
- Year of manufacture
- Type and serial number
- Rated voltage (kV)

- Rated impulse withstand voltage (kV)
- Rated power frequency withstand voltage (kV)
- Rated frequency (Hz)
- Rated current of equipment (A)
- Rated current of busbars (A)
- Rated short-time withstand current (kA)
- Rated peak current (kA)
- Rated duration of short-circuit (s)
- Rated short-circuit breaking current of circuit breaker (A)
- Rated duty cycle of circuit breaker
- $SF_6$ pressure at $20^o$ C (bar) for all modules
- Weight of required $SF_6$ for the bay
- Weight of bay including $SF_6$
- Standards according to which the bay has been manufactured

After placement of the order the respective texts shall be submitted for approval.

At the front of the bay a removable plate shall be placed whereon the Seller will engrave the name of the bay (e.g. overhead line, etc.).

Plates shall be also placed near the handles showing the positions ON-OFF as well as their respective direction of movement.

## 11. Inspection, Maintenance, Repair, Extension and Accessibility Requirements

The contractor will guarantee the following:

1. For routine inspections, all elements shall be accessible without removal of supporting structures. The removal of individual enclosure parts or complete switchgear bays shall be possible with the minimum disturbance of the neighbouring bays.

2. Routine maintenance of external parts of the switchgear including instrument transformers shall not be necessary at intervals of less than 5 years.

3. The maintenance intervals of the circuit breaker shall not be less than 15 rated short circuit current interruptions, or 2000 rated current interruptions or 20 years operation whichever is earlier. Maintenance activities shall comprise only simple inspections and no exchange of parts or complex adjustments.

4. Checking the contact condition of the interrupter unit of the circuit breaker shall be possible without disturbing any other gas compartment and without interrupting any hydraulic piping. It shall be possible to safely replace the interrupter contacts of the circuit breaker even while the remaining switchgear is "live". The circuit breaker enclosure shall have provisions for easy withdrawal of the contact assembly. This procedure shall not involve the removal or dislocation for neighbouring bay enclosure parts. The removed interrupter assembly shall be easily and safely accessible for inspections and possible repairs.
5. Each bay shall be equipped with two buffer chambers between the busbar disconnector compartment and the circuit breaker compartment in order to ensure the uninterrupted operation of the two busbars in case of maintenance or repair of the bay. The adjacent bays shall continue to operate uninterrupted.
6. Two busbar buffer chambers with transversal insertion shall be foreseen at both sides of selected bays (as they are defined at the Inquiry) in order to ensure the uninterrupted operation of the bay, during maintenance or repair of the busbar disconnector compartment of the adjacent bays.
7. In case of future extension, a buffer chamber shall be foreseen at the end of the busbars (at the extension side) in order to ensure that the adjacent to the extension bay shall operate uninterrupted.
8. No work is allowed next to gas compartments at rated pressure either energized or de-energized.

## 12. Packing and Transport

### 12.1. General Packing

The equipment shall be delivered in the highest possible assembled form. The packing shall include at least the following:

a. Wooden frames protecting all the edges from blows and impacts during transport and shipping. Each side shall be also protected by χ-planks.

b. Plastic wrapping shall protect the equipment from moisture, dust, etc.

c. The flat surfaces shall be protected from mechanical stresses by means of corrugated cardboard lining or plastic lining with air inclusions or sheets of volume expanded polystyrene placed inside the plastic wrapping.

The delivery shall be complete. All the components, devices, endboxes, wirings, etc., as well as every removable element, must be fitted on the respective bay or packed with it, taking care that no damage or injury would arise during transport.

### 12.2. Shock Recorders for Transport

One shock recorder will be provided and installed on each major switchgear assembly or part (such as Circuit Breaker, Current Transformer, Voltage Transformer etc.) by the manufacturer, in order to record all horizontal and vertical impacts suffered during transport from factory to site.
The shock recorders will be of digital type and they will include GPS and time tagging of the recordings. They will be SMT HYBRID – MONILOG ENDAL or SHOCKWATCH – SHOCK LOG 298 or MESSKO – CARGOLOG or of an equivalent type, subject to IPTO's approval.

The alarm limit of shock recorders will be set below 5g acceleration,

The recorder is to be operative from the time of packing to unpacking on site, in order to provide an uninterrupted record of all registered data. The recorder is to be suitably sealed so that only IPTO's authorized personnel shall collect the registered data upon arrival at site. An appropriate manual shall be supplied to the Purchaser.

## 13. Documents

### 13.1. Documents to be submitted by the bidder

The Supplier shall, together with his offer, submit in three copies all documents with information necessary for the evaluation of the bids, such as certificates, drawings, technical leaflets, etc. The information shall indispensably comprise the following:

1. Drawings of the switchgear complete with the components (circuit breakers, isolators, earthing switches. current transformers, etc.), outline dimensions, weights and other data which may be needed for the installation of the switchgear under the given service conditions.

2. Technical leaflets for all types of bays, modules and accessories (circuit breakers, etc.).

3. Preliminary outline drawings of the offered GIS

4. Single-line diagram of the offered GIS

5. A gas compartment diagram where the different gas compartments are clearly defined

6. Complete description of all interlocks employed

7. Complete description of all high speed earthing switches used and their location in the GIS.

8. A table comprising all technical data of the individual devices of the bays offered. Such particulars shall be supported by corresponding information prospectuses of the manufacturer of these devises or by relevant test certificates.

9. Detailed information on the constructional characteristics of the switchgear.

10. Finally the Manufacturer shall furnish detailed information of any deviation of the material offered from the requirements of this technical description, if not mentioned in the above paragraphs.

11. Bidders are required to answer all items of “Attachment A” . Failure to comply will result in ejection of the offer.

Furnishing the above information is mandatory for the Manufacturer. It is recommended that the data requested shall be given clearly, a mere affirmative or negative reply will not be sufficient. Bids not comprising all the foregoing data will be rejected.

In case of no mentioning of any differences, the material will be considered to comply with the Technical Description.

### 13.2. Documents submitted by the contractor

1. After placement of the order, the Seller shall submit for approval four (4) sets of detailed outline, schematic and wiring drawings.

2. The Seller shall submit, at least one month before the inspection notice, four (4) sets of detailed instructions for installation, operation and maintenance of the equipment.

3. Any delay in submitting the above drawings and instructions owing to the Seller will be regarded as a delay in execution of the contract.

### 14. Spare Parts

a. The spare parts included in the “Table of Essential Spare Parts (L-1)” of the Inquiry shall be delivered together with the bays. The cost of these spare parts shall included in the economic offer.

b. If the Seller considers some additional spare parts should be offered, he should include them in the separate list of “Table of Recommended Spare Parts (L-2)” of the Inquiry. The Purchaser shall determine during the contract signature which of these spare parts, if any, and in what amount will be included in the order.

### 15. Warranty

The contractor must provide a warranty of the three (3) years beginning from the date of delivery of the GIS for any damages by faulty design or by unreliable components or by combination of the two.

## ANNEX A
## REQUIREMENTS FOR OUTDOOR INSTALLATION

If the GIS will be installed outdoors, the following changes will be applied to the present specification:

- In par.3, the corrosivity category of the atmosphere will be changed from C3 to C4.

- In par.7.1.1.10 an additional requirement for weatherproof housing of the operating mechanism fixed on the base frame of the breaker.

- In par.7.13, the weatherproofing of all operating mechanisms and cubicles installed outdoors will be changed from IP42 to IP54. Especially for Local Control Cubicles, an inspection window for the mimic diagram shall be foreseen.

- In par.9.1, the following tests will be added to the special tests, performed on a typical GIS bay of the delivery, only if the corresponding type test certificates are older than eight (8) years from the tender date or not existing:

    - IP degree verification (IP 54) according to IEC 60529 for all control and signaling boxes and for all accessories (instruments, sensors, etc.). Additionally weatherproofing test on a full bay of typical composition, according to IEC 62271-1, Annex C.

    - IK degree verification (IK 10) according to IEC 62262 for all control and signaling boxes.

    - Tightness test and mechanical tests according to IEC 62271-203, par. 6.8 and 6.102 for limit temperatures -5°C and +50°C.

    - Solar radiation test according to IEC 60068-2-5, procedure B, for the partitions and all accessories (instruments, sensors, etc.), which are exposed to solar radiation.

## ANNEX B

## ONLINE PARTIAL DISCHARGE MONITORING SYSTEM IN GIS/GIL

### 1. General

Partial Discharge Monitoring system (PDM) shall be supplied for UHF online monitoring of Partial Discharge (PD) in GIS/GIL. The contractor shall be responsible for the design, supply, delivery, installation, site testing and commissioning of the complete PDM system.
On the GIS/GIL, a partial discharge monitoring system (PDM, the System) shall continuously collect partial discharge data using UHF technique from the monitored couplers (sensors). The partial discharge data shall be stored locally and transferred automatically to a remote location at intervals. The users must be able to access the data through web and client-server interfaces.
The System shall be able to indicate to the operator at a remote location (e.g. headquarters, maintenance/operation centre etc. through SMS, e-mail or mobile app) when the transferred data indicates partial discharge behaviour which requires his attention. On receiving such an indication, the operator shall be able to retrieve and display partial discharge data from the coupler concerned to enable him to decide on action to be taken.
The remote access to PDM system must be provided via separate web access, based on TCP/IP, through the server located at IPTO's data centre.
The partial discharge data shall be displayed in a way that allows the operator to recognise the type of defect present and indicate an increase in severity (trend analysis). It shall be necessary to be able to recognise signals from partial discharges, switching operations and external sources of interference. Automatic classification of PD through Expert System shall be provided. Access to partial discharge data and System administration functions shall be protected by password.

### 2. Specification for Internal Couplers

The GIS must be fitted with internal UHF PD couplers. PD couplers must be fitted in a way that GIS meets sensitivity according to **CIGRE Guide no 654 "UHF partial discharge detection system for GIS: Application Guide for Sensitivity verification"** at every place in the GIS/GIL (5pC or better). Specification of PD couplers supplied and installed in GIS equipment by contractor shall be as below:

- The coupler shall be passive, maintenance free antenna type, **installed in every gas tight GIS compartment at minimum**
- The coupler shall be sensitive between 200 to 2000MHz frequency
- Internal PD coupler shall meet the following sensitivity levels (tested using a GTEM horn)
- The internal dimensions of UHF PD sensors must be of the same order as the wavelengths pf the measured frequencies

- Working temperature range: -25° C to +120° C
- Maximum working humidity: 100%
- IP rating: IP54
- UHF Connection shall be of N Type with an impedance of 50 or 75Ω (Ohm)
- The PD calibrator (PD pulse injection equipment) shall be provided along with the system
- Contractor shall have supply record of supplying barrier couplers for at least three (3) GIS projects with minimum total fifteen (15) bays configuration

## 3. Specification for Partial Discharge Monitoring System (PDM)

The online PD monitoring must be equipped with following key features:

- Meet sensitivity according to **CIGRE TF15/33.03.05 and CIGRE Guide No.654** at every place in the GIS/GIL (5pC or better) will be verified as part of site sensitivity tests.
- Continuous real-time measurement and PD analysis; not multiplexed data collection.
- The system shall have individual channel control.
- Node data connection must support both Copper Ethernet and Multi-Mode Fibre Optic.
- Node communication must be by Ethernet, scalable, industrial standard between data nodes central server. The system shall have capability to support 500 UHF sensors or more.
- Each UHF node will support a minimum of 6 continuously active input UHF Channels and 1 UHF noise channel.
- Support Simple Network Time Protocol (SNTP).
- Fixed broadband monitoring (bandwidth >=1 GHz)
- Historical PRPD over 5, 10 or 15 minutes recording period (software selectable).
- Minimum noise detection and suppression facilities:
  - Smart Gating with external type noise antenna.
  - Artificial Intelligence Software detection package. Artificial Intelligence and Neural Network based pattern recognition algorithms should be conditioned over an extensive real PD pattern database.
- UHF Signal classification (5 pattern types or more) for GIS/GIL by an Expert System and the analysis result shall be clearly indicated to the operator. The PDM System shall combine Artificial Neural Networks (ANNS), Genetic Algorithms (GAs) and Fuzzy logic.
- The PDM System shall be able to discriminate between partial discharge sources, external interference and transients, resulting from switching operations of the high-voltage equipment.
- PD Alarm setting module for configuration of all PD alarms within substations.

- Ability to call and display, within Application software, 2-Dimensional GIS Schematics showing spatial relationship between couplers in the GIS/GIL.
- Ability to select standard and high resolution sampling, 8 or 10 bits and 64 or 256 samples per 50Hz power cycle.
- The System shall be capable of synchronizing, capturing and displaying PD data for a power test frequency in the range 40Hz÷150Hz (or wider range). The System shall be capable of operation during HV testing of the GIS/GIL.
- The PDM System shall be designed to operate from substation auxiliary supplies. Failure of auxiliary supply to the System shall be sensed and alarmed by the System.
- The System application software shall incorporate function for the complete recording of PD activity during GIS/GIL HV tests. The function shall allow complete review of PD activity during or after the test.
- PD source localization using the time-of-flight (TOF) techniques is desirable.
- The System shall have a PC at a headquarters location with remote application software which can automatically support remote accessing for up to 250 substations.
- The PDM Supplier shall have a proven history of operation at a minimum of five (5) independent substations, each for a minimum of three (3) years. In the tender proposal the tenderer shall provide following information history and be prepared to support those claims with reference from the respective:
  - Complete List of same PDM system type installations indicating for each installation:
    - Year of installation
    - Country and End-user
    - GIS/GIL Voltage level
  - End-user Reference letters (at least two).
- The System shall be sensitive to partial discharge signals throughout the frequency range 300MHz – 1200MHz. However, it is recognised that in some cases the use of filters may be necessary to reduce the sensitivity of the System at certain frequencies to signals arising from telecommunications and other external sources. The system shall provide flexibility to select following frequency ranges without adding separate hardware filter (indicative frequency ranges):
  - 300MHz to 800 MHz
  - 300MHz to 1200 MHz
  - 440MHz to 800 MHz
- The System shall have a signal sensitivity of up to -80dBm.
- History data shall be recorded every 1.5, 5, 10 or 15 minutes (indicative time software selectable). History plots shall be capable of being displayed over a period of 1 year.

- The HMI system shall be equipped with Relational Database Management System (RDBMS) which is:
  - Microsoft ODBC (Open Database Connectivity) specification compliant.
  - ANSI 92 SQL (Structured Query Language) compliant.
- Both the substation and Headquarters shall allow the data from no less than six coupling devices to be displayed simultaneously, such that data from different couplers at different times may be displayed.
- Data shall be displayed in the following formats (indicative):
  - 3 dimensional oblique, snapshot and real time
  - 2 dimensional point on wave; both amplitude and discharge rate
  - PRPD online and historical
  - STT (short term trends)
  - 24-hour summary
- PDM system shall have dynamic range up to 70dBm for at least 10 frequencies between 300MHz to 1200MHz to enable display of PD signals with varying amplitude. The trending shall support showing amplitude with varying ranges of PD signals (-15dBm to -75dBm or better).
- The Headquarters shall include a data synchronization function that shall allow any missing data to be downloaded from any substation for a period of up to one year.
- System shall record switching transient generated by CBs (Circuit Breakers) and disconnectors. (Optional analysis of switching patterns).
- The PDM system shall have capability to expand into complete GIS condition monitoring systems. It shall support integration with SF6 leakage monitoring system and Breaker Condition Monitoring system. It shall support industry standard protocols, IEC61850for data integration with the monitoring systems. In case IEC 61850 is not implemented throughout the substation control network, Modbus and DNP3.0 protocols are also accepted. The additional condition monitoring system is not part of the scope of the current technical description.
- The System shall be type tested by independent accredited test house to following IEC standards for EMC & Environmental for use within EHV substations.

| Standard | Description |
|---|---|
| ES BN 55022 (CISPR22) | Conducted emissions |
| IEC 60068-2-1 | Low temperature |
| IEC 60068-2-2 | Dry heat |
| IEC 60068-2-6 | Vibration |
| IEC 60068-2-27 | Shock |
| IEC 60068-2-56 | Damp heat |
| IEC 60255-5 | Dielectric withstand |
| IEC 61000-4-2 | Electrostatic discharge |
| IEC 61000-4-3 | Radiated immunity |
| IEC 61000-4-4 | Fast transient |
| IEC 61000-4-5 | Surge |

| | |
|---|---|
| IEC 61000-4-6 | Conducted immunity |
| IEC 61000-4-8 | Power frequency magnetic field |
| IEC 61000-4-9 | Pulsed magnetic field |
| IEC 61000-4-10 | Damped oscillatory magnetic field |
| IEC 61000-4-12 | Damped oscillatory wave |

## ANNEX C

## 170 kV $SF_6$ GAS INSULATED METAL-ENCLOSED SWITCHGEAR (GIS)

## INFORMATION BY SELLER

| Index | | | Technical data | (Units) | (Technical data of the offered equipment) | (Technical deviation/ justification/ remarks) |
|---|---|---|---|---|---|---|
| **1** | | | **170 kV GIS EQUIPMENT** | | | |
| | 1 | | Standards | | | |
| | 2 | | Manufacturer/Type | | | |
| | 3 | | Material of the enclosure | | | |
| | 4 | | Number of phases inside the enclosure | | | |
| | | 1 | -for Busbars | | | |
| | | 2 | -for Bays | | | |
| | 5 | | Rated voltage | kV | | |
| | 6 | | Operating voltage | kV | | |
| | 7 | | Busbars rated current | A | | |
| | 8 | | Overhead line bays rated current | A | | |
| | 9 | | Bus coupler rated current | A | | |
| | 10 | | Transformer bays rated current | A | | |
| | 11 | | Rated short-time current (1s) | kA | | |
| | 12 | | Rated peak withstand current | kA | | |
| | 13 | | Rated duration of the short circuit | sec | | |
| | 14 | | Rated frequency | Hz | | |
| | 15 | | Maximum guaranteed gas losses from any compartment | % / yr | | |
| | 16 | | Interval for gas replenishment based upon guaranteed leakage rate | yr | | |
| | 17 | | Rated gas pressure (gauge) at 20°C | bar-g | | |
| | 18 | | Gas alarm level (gauge) at 20°C | | | |
| | | 1 | -Loss of $SF_6$ (St1) | bar-g | | |
| | | 2 | -Minimum $SF_6$ density (St2) | bar-g | | |
| **1.1** | | | **170 kV GIS CIRCUIT BREAKERS** | | | |
| **1.1.1** | | | **170 kV GIS CIRCUIT BREAKER 3150 A** | | | |
| | 1 | | Rated normal current | | | |
| | | 1 | -for OHL bay | A | | |
| | | 2 | -for Bus Coupler bays | A | | |
| | | 3 | -for Busbars | A | | |
| | 2 | | Rated short-circuit breaking current (at 170 kV) | | | |
| | | 1 | -rms value of A.C. component | kA | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | 2 | -percentage of D.C. component | | | |
| | 3 | | Rated transient recovery characteristics for terminal faults corresponding to 100% of rated short-circuit breaking current | | | |
| | | 1 | -First-pole-to-clear factor | | | |
| | | 2 | -Rated transient recovery voltage | kV | | |
| | | 3 | -Rate of rise of recovery voltage (RRRV) | kV/µs | | |
| | 4 | | Rated short-circuit making current | kA | | |
| | 5 | | Rated short circuit duration | s | | |
| | 6 | | Rated operation cycle | | | |
| | 7 | | Interruption duty | | | |
| | | 1 | -Has the C.B. shunt reactor load switching capability according to IEC 62270-110? | | | |
| | | 2 | -Is the C.B. able to interrupt overhead line charging currents of 63 A, with class C2, according to IEC 62271-100? | | | |
| | | 3 | -Is the C.B. able to interrupt capacitive cable charging currents up to 160 A, with class C2, according to IEC 62271-100? | | | |
| | 8 | | Rated transient recovery characteristics for short-line faults | | | |
| | | 1 | -Rated transient recovery voltage | kV | | |
| | | 2 | -First-pole-to-clear factor | | | |
| | | 3 | -Rate of rise of recovery voltage (RRRV) | kV/µs | | |
| | 9 | | Mechanical endurance class | | | |
| | 10 | | Interrupting time (maximum interval between energisation of the tripping coil and interrution of the main circuit in all poles of the breaker) | | | |
| | | 1 | -at 100% of the rated breaking capacity | ms | | |
| | | 2 | -at 10%, 30%, 60% of the rated breaking capacity | ms | | |
| | 11 | | Fault clearance time (overall fault clearance time including relay operating time) | ms | | |
| | 12 | | Operating time diversion between breaker poles and between breaks of each pole, on closing or tripping | ms | | |
| | 13 | | Make time (interval between the energisation of the closing coil and the instant when the current begins to flow in the main) | ms | | |
| | 14 | | Dead time between opening and closing | s | | |
| | 15 | | Rated out-of-phase breaking current | A | | |
| | 16 | | Number of tripping coils | | | |
| | 17 | | Number of closing coils | | | |
| | 18 | | Supply voltage of tripping and closing coils | V | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | 19 | | Tolerances of the supply voltage of the tripping coils | | | |
| | 20 | | Tolerances of the supply voltage of the closing coils | | | |
| | 21 | | Power consumption | | | |
| | | 1 | Closing coil (DC) | VA | | |
| | | 2 | Trip coil (DC) | VA | | |
| | 22 | | Can the breaker be operated in case of DC auxiliary supply voltage loss or charging motor failure? | | | |
| | 23 | | Rated gas pressure (gauge) at 20°C | bar-g | | |
| | 24 | | Gas alarm level (gauge) at 20°C | | | |
| | | 1 | -Loss of $SF_6$ (St1) | bar-g | | |
| | | 2 | -Minimum $SF_6$ density (St2) | bar-g | | |
| | 25 | | Arc quenching medium ( $SF_6$) | | | |
| | | 1 | Rated pressure of $SF_6$ | bar | | |
| | | 2 | $SF_6$ alarm pressure | bar | | |
| | | 3 | $SF_6$ lockout pressure | bar | | |
| | | 4 | $SF_6$ loss | %/year | | |
| | | 5 | Mass of $SF_6$ for the entire breaker | kg | | |
| | | 6 | Minimum $SF_6$ operating pressure | bar | | |
| | 26 | | Type of operating mechanism | | | |
| | 27 | | Does the C.B. consist of 3 separate single-phase units with a common operating device? | | | |
| | 28 | | If yes, then | | | |
| | | 1 | -Are the units coupled so that their accurate alignment is not necessary and so that any unit can readily be replaced by a spare unit? | | | |
| | | 2 | -Is it possible to make independent adjustment on each unit? | | | |
| | | 3 | -Is the operation of the 3 single-phase units simultaneous? | | | |
| **1.1.2** | | | **170 kV GIS CIRCUIT BREAKER 1250 A** | | | |
| | 1 | | Rated normal current | | | |
| | | 1 | -for OHL bay | A | | |
| | | 2 | -for Bus Coupler bays | A | | |
| | | 3 | -for Busbars | A | | |
| | 2 | | Rated short-circuit breaking current (at 170 kV) | | | |
| | | 1 | -rms value of A.C. component | kA | | |
| | | 2 | -percentage of D.C. component | | | |
| | 3 | | Rated transient recovery characteristics for terminal faults corresponding to 100% of rated short-circuit breaking current | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | 1 | -First-pole-to-clear factor | | | |
| | | 2 | -Rated transient recovery voltage | kV | | |
| | | 3 | -Rate of rise of recovery voltage (RRRV) | kV/µs | | |
| | 4 | | Rated short-circuit making current | kA | | |
| | 5 | | Rated short circuit duration | s | | |
| | 6 | | Rated operation cycle | | | |
| | 7 | | Interruption duty | | | |
| | | 1 | -Has the C.B. shunt reactor load switching capability according to IEC 62270-110? | | | |
| | | 2 | -Is the C.B. able to interrupt overhead line charging currents of 63 A, with class C2, according to IEC 62271-100? | | | |
| | | 3 | -Is the C.B. able to interrupt capacitive cable charging currents up to 160 A, with class C2, according to IEC 62271-100? | | | |
| | 8 | | Rated transient recovery characteristics for short-line faults | | | |
| | | 1 | -Rated transient recovery voltage | kV | | |
| | | 2 | -First-pole-to-clear factor | | | |
| | | 3 | -Rate of rise of recovery voltage (RRRV) | kV/µs | | |
| | 9 | | Mechanical endurance class | | | |
| | 10 | | Interrupting time (maximum interval between energisation of the tripping coil and interrution of the main circuit in all poles of the breaker) | | | |
| | | 1 | -at 100% of the rated breaking capacity | ms | | |
| | | 2 | -at 10%, 30%, 60% of the rated breaking capacity | ms | | |
| | 11 | | Fault clearance time (overall fault clearance time icluding relay operating time) | ms | | |
| | 12 | | Operating time diversion between breaker poles and between breaks of each pole,on closing or tripping | ms | | |
| | 13 | | Make time (interval between the energisation of the closing coil and the instant when the current begins to flow in the main) | ms | | |
| | 14 | | Dead time between opening and closing | s | | |
| | 15 | | Rated out-of-phase breaking current | A | | |
| | 16 | | Number of tripping coils | | | |
| | 17 | | Number of closing coils | | | |
| | 18 | | Supply voltage of tripping and closing coils | V | | |
| | 19 | | Tolerances of the supply voltage of the tripping coils | | | |
| | 20 | | Tolerances of the supply voltage of the closing coils | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | 21 | | Power consumption | | | |
| | | 1 | Closing coil (DC) | VA | | |
| | | 2 | Trip coil (DC) | VA | | |
| | 22 | | Can the breaker be operated in case of DC auxiliary supply voltage loss or charging motor failure? | | | |
| | 23 | | Rated gas pressure (gauge) at 20°C | bar-g | | |
| | 24 | | Gas alarm level (gauge) at 20°C | | | |
| | | 1 | -Loss of $SF_6$ (St1) | bar-g | | |
| | | 2 | -Minimum $SF_6$ density (St2) | bar-g | | |
| | 25 | | Arc quenching medium ( $SF_6$) | | | |
| | | 1 | Rated pressure of $SF_6$ | bar | | |
| | | 2 | $SF_6$ alarm pressure | bar | | |
| | | 3 | $SF_6$ lockout pressure | bar | | |
| | | 4 | $SF_6$ loss | %/year | | |
| | | 5 | Mass of $SF_6$ for the entire breaker | kg | | |
| | | 6 | Minimum $SF_6$ operating pressure | bar | | |
| | 26 | | Type of operating mechanism | | | |
| | 27 | | Does the C.B. consist of 3 separate single-phase units with a common operating device? | | | |
| | 28 | | If yes, then | | | |
| | | 1 | -Are the units coupled so that their accurate alignment is not necessary and so that any unit can readily be replaced by a spare unit? | | | |
| | | 2 | -Is it possible to make independent adjustment on each unit? | | | |
| | | 3 | -Is the operation of the 3 single-phase units simultaneous? | | | |
| **1.2** | | | **170 kV GIS Disconnectors** | | | |
| **1.2.1** | | | **Bay Disconnectors 3150 A** | | | |
| | 1 | | Rated normal current | A | | |
| | 2 | | Rated short-time withstand current (1 s) | kA | | |
| | 3 | | Rated peak withstand current | kA | | |
| | 4 | | Rated short-circuit breaking current | kA | | |
| | 5 | | Rated closing/opening time | s | | |
| **1.2.2** | | | **Bay Disconnectors 1250 A** | | | |
| | 1 | | Rated normal current | A | | |
| | 2 | | Rated short-time withstand current (1 s) | kA | | |
| | 3 | | Rated peak withstand current | kA | | |
| | 4 | | Rated short-circuit breaking current | kA | | |
| | 5 | | Rated closing/opening time | s | | |
| **1.2.3** | | | **Busbar Disconnectors** | | | |
| | 1 | | Rated normal current | A | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | 2 | | Rated short-time withstand current (1 s) | kA | | |
| | 3 | | Rated peak withstand current | kA | | |
| | 4 | | Rated short-circuit breaking current | kA | | |
| | 5 | | Rated closing/opening time | s | | |
| **1.3** | | | **170 kV GIS Earthing Switches** | | | |
| **1.3.1** | | | **Maintenance earthing switches** | | | |
| | 1 | | Rated normal current | A | | |
| | 2 | | Rated short-time withstand current (1 s) | kA | | |
| | 3 | | Rated peak withstand current | kA | | |
| **1.3.2** | | | **High Speed Earthing Switches** | | | |
| | 1 | | Rated normal current | A | | |
| | 2 | | Rated short-time withstand current (1s) | kA | | |
| | 3 | | Rated peak withstand current | kA | | |
| **1.4** | | | **170 kV GIS Current Transformers** | | | |
| **1.4.1** | | | **CTs of bay for cable connection with OHL** | | | |
| | 1 | | Ratio | A | | |
| | 2 | | Rated short-time withstand current 1s (primary winding) | kA | | |
| | 3 | | Rated peak withstand current (primary winding) | kA | | |
| | 4 | | Winding No 1 | | | |
| | | 1 | -Rated Burden | VA | | |
| | | 2 | -Class | | | |
| | | 3 | -Overcurrent Factor | | | |
| | 5 | | Winding No 2 | | | |
| | | 1 | -Rated Burden | VA | | |
| | | 2 | -Class | | | |
| | | 3 | -Overcurrent Factor | | | |
| | 6 | | Winding No 3 | | | |
| | | 1 | -Rated Burden | VA | | |
| | | 2 | -Class | | | |
| | | 3 | -Overcurrent Factor | | | |
| | 7 | | Winding No 4 | | | |
| | | 1 | -Rated Burden | VA | | |
| | | 2 | -Class | | | |
| | | 3 | -Overcurrent Factor | | | |
| **1.4.2** | | | **CTs of bay for connection with a power T/F** | | | |
| | 1 | | Ratio | A | | |
| | 2 | | Rated short-time withstand current 1 s (primary winding) | kA | | |
| | 3 | | Rated peak withstand current (primary winding) | kA | | |
| | 4 | | Winding No 1 | | | |
| | | 1 | -Rated Burden | VA | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | 2 | -Class | | | |
| | | 3 | -Overcurrent Factor | | | |
| | 5 | | Winding No 2 | | | |
| | | 1 | -Rated Burden | VA | | |
| | | 2 | -Class | | | |
| | | 3 | -Overcurrent Factor | | | |
| | 6 | | Winding No 3 | | | |
| | | 1 | -Rated Burden | VA | | |
| | | 2 | -Class | | | |
| | | 3 | -Overcurrent Factor | | | |
| | 7 | | Winding No 4 | | | |
| | | 1 | -Rated Burden | VA | | |
| | | 2 | -Class | | | |
| | | 3 | -Overcurrent Factor | | | |
| **1.4.3** | | | **CTs of Bus Coupler Bay** | | | |
| **1.4.3(a)** | | | **From the one side of the 170 kV CB** | | | |
| | 1 | | Ratio | A | | |
| | 2 | | Rated short-time withstand current 1 s (primary winding) | kA | | |
| | 3 | | Rated peak withstand current (primary winding) | kA | | |
| | 4 | | Winding No 1 for busbar differential protection | | | |
| | | 1 | -Rated Burden | VA | | |
| | | 2 | -Class | | | |
| | | 3 | -Overcurrent Factor | | | |
| **1.4.3(b)** | | | **From the other side of the 170 kV CB** | | | |
| | 1 | | Ratio | A | | |
| | 2 | | Rated short-time withstand current (1 s) | kA | | |
| | 3 | | Rated peak withstand current | kA | | |
| | 4 | | Winding No 1 for busbar differential protection | | | |
| | | 1 | -Rated Burden | VA | | |
| | | 2 | -Class | | | |
| | | 3 | -Overcurrent Factor | | | |
| | 5 | | Winding No 2 for measurements | | | |
| | | 1 | -Rated Burden | VA | | |
| | | 2 | -Class | | | |
| | | 3 | -Overcurrent Factor | | | |
| **1.5** | | | **170 kV GIS Voltage Transformers** | | | |
| **1.5.1** | | | **VTs of bay for cable connection with OHL** | | | |
| | 1 | | Ratio | V | | |
| | 2 | | Winding No 1 | | | |
| | | 1 | -Rated Burden | VA | | |
| | | 2 | -Class | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | 3 | | Winding No 2 | | | |
| | | 1 | -Rated Burden | VA | | |
| | | 2 | -Class | | | |
| | 4 | | Winding No 3 | | | |
| | | 1 | -Rated Burden | VA | | |
| | | 2 | -Class | | | |
| | 5 | | Maximum total continuous burden | VA | | |
| **1.5.2** | | | **VTs of bay for connection with a power T/F** | | | |
| | 1 | | Ratio | V | | |
| | 2 | | Winding No 1 | | | |
| | | 1 | -Rated Burden | VA | | |
| | | 2 | -Class | | | |
| | 3 | | Winding No 2 | | | |
| | | 1 | -Rated Burden | VA | | |
| | | 2 | -Class | | | |
| | 4 | | Maximum total continuous burden | VA | | |
| **1.5.3** | | | **Busbar Voltage Transformers** | | | |
| | 1 | | Ratio | V | | |
| | 2 | | Winding No 1 for measuring | | | |
| | | 1 | -Rated Burden | VA | | |
| | | 2 | -Class | | | |
| | 3 | | Winding No 2 for synchronizing purposes | | | |
| | | 1 | -Rated Burden | VA | | |
| | | 2 | -Class | | | |
| | 4 | | Maximum total continuous burden | VA | | |
| **1.6** | | | **$SF_6$ to Cable connection** | | | |
| | 1 | | Manufacturer | | | |
| | 2 | | Type | | | |
| | 3 | | Temperature range | | | |
| | 4 | | Short-circuit level | kA | | |
| | 5 | | Rated short-time withstand current 1 s (primary winding) | kA | | |
| | 6 | | Lightning Impulse Voltage Withstand (peak) | kV | | |
| | 7 | | Power Frequency Withstand Voltage (1 min, 50 Hz) | kV | | |
| | 8 | | Rated operating current at 170 kV | A | | |
| | 9 | | Material of insulation | | | |
| | 10 | | Insulation level | | | |
| **1.7** | | | **$SF_6$ to air bushings** | | | |
| | 1 | | Manufacturer | | | |
| | 2 | | Type | | | |
| | 3 | | Standards | | | |
| | 4 | | Enclosure material | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | 5 | | Flashover distance | mm | | |
| | 6 | | Creepage distance | mm | | |
| **1.8** | | | **150 kV GIS Surge Arresters** | | | |
| | 1 | | Continuous operating voltage (COV) Uc | kV | | |
| | 2 | | Rated voltage, Ur | kV | | |
| | 3 | | Rated frequency | Hz | | |
| | 4 | | Nominal discharge current (8/20µç) | kA | | |
| | 5 | | High current impulse withstand | kA | | |
| | 6 | | Rated short circuit current Is | kA | | |
| | 7 | | Classification | | | |
| | | 1 | -class | | | |
| | | 2 | -duty | | | |
| | | 3 | -designation | | | |
| | | 4 | -thermal energy rating Wth | kJ/kV | | |
| | | 5 | -repetitive charge transfer rating Qrs | C | | |
| | 8 | | Residual voltage at 1 kA switching current impulse (>30/60 µs) (SIPL) | kV | | |
| | 9 | | Residual voltage at 10 kA lighting current impulse (8/20 µs) (LIPL) | kV | | |
| **1.9** | | | **GIS Design** | | | |
| | 1 | | Does the design of the GIS satisfy the requirements of § 11? | | | |
| **2.0** | | | **Partial Discharge Monitoring System (PDM)** | | | |
| | 1 | | Is an online partial discharge monitoring system offered? | | | |
| | 2 | | Manufacturer | | | |
| | 3 | | Is it according to Annex B of TD-29/13? | | | |