

**Technical Specification for
SF6 GAS INSULATED METAL
ENCLOSED SWITCHGEAR
(GIS) and Accessories
rated 245kV, 145kV & 72.5kV**

(for 220kV S/Stn)

SPECIFICATION No.:

S-38/DGMS- 235

CHIEF ENGINEER/PD&C,

HVPNL, PANCHKULA

OCT-2023

Revision Note

SR No	Revision No	Clause No.	Remarks
1	S-38/DGMS-235 dated ____10.2023	Clause No 21.1	<i>"The type test reports shall be considered valid irrespective of the validity of their time period provided no major change has been introduced in the basic design technology/ functionalities of the equipment /performance characteristics/ manufacturing process"</i> As conveyed vide Company Secretary, HVPNL, Panchkula vide U.O. no. 8476/BODs/28.09.2023 dt. 10.10.2023

Index

Sr. No.	Description	Page No.
1.0	General Characteristics	3
2.0	Reference Standards	4
3.0	Definitions	4
4.0	General Design & Safety Requirement	5
5.0	Bellows or Compensating Units:-	8
6.0	Indication and Verification of Switch Positions	8
7.0	Pressure Relief Devices	8
8.0	Pressure Vessel Requirements	9
9.0	Circuit Breakers	9
10.0	Disconnectors (Isolators)	13
11.0	Safety Grounding Switches	15
12.0	High Speed Make Proof Grounding Switches	16
13.0	Instrument Transformers	17
14.0	Surge Arrestors	19
15.0	Seismic Design Criteria:	20
16.0	Quality of SF6 Gas	20
17.0	SF6 Gas Monitoring Devices and Alarm Circuits	20-21
18.0	Painting of Enclosure	21
19.0	Heaters	21
20.0	Identification & Rating Plate	21
21.0	Tests	21-22
22.0	TRANSPORT OF EQUIPMENT TO SITE.	22
23.0	PACKING, STORAGE AND UNPACKING	22-23
24.	Grounding	23-24
25.0	220 kV, 132kV & 66 kV GIS BUILDING	24
26.0	Gas Filling and Evacuating Plant	24-25
27.0	Outdoor Termination Kit	25
28.0	SF6 GIS to XLPE Cable Termination	25
29.0	Electric Overhead Crane	25-26
30.0	Partial Discharge Monitoring System & Dew Point Meter etc.,	26
ANNEXURES	Core-wise Details of 245/145/72.5kV T/F CT/Line CT/Bus Coupler CT/T/F I/C CT/PT	27-32
ANNEXURE A	TECHNICAL SPECIFICATION FOR SPECIAL EQUIPMENTS	33-37

**TECHNICAL SPECIFICATION FOR
SF6 GAS INSULATED METAL ENCLOSED SWITCHGEAR (GIS) and Accessories
RATED 245kV, 145kV & 72.5kV**

1.0 General Characteristics

The SF6 gas insulated metal enclosed switchgear shall be totally safe against inadvertent touch of any of its live constituent parts. It should be designed for indoor (as specified) application with meteorological conditions at site as per Section Project. All parts of the switchgear should be single phase/three phase enclosed for 220kV GIS, 132kV GIS & 66kV GIS with current rating as under:-

Sr.No.	Voltage Level	Bus Bar	Bus Coupler Bay Module	Feeder and Transformer Bay Module
1	220kV	2000A	2000	1250A
2	132kV	2000A	2000	1250A
3	66kV	3150A	2000	2000A

However the type of enclosure whether single or three phase at each voltage level to be identified by the bidder at the time of bidding and quoted accordingly which will not be altered at later stage.

The arrangement of gas sections or compartments shall be such as to facilitate future extension of any make on either end without any drilling, cutting or welding on the existing equipment. To add equipment, it shall not be necessary to move or dislocate the existing switchgear bays. The design should be such that all parts subjected to wear and tear are easily accessible for maintenance purposes. The equipment offered shall be protected against all types of voltage surges and any equipment necessary to satisfy this requirement shall be deemed to be included

The required overall parameters of GIS are as follows:-

S. No	Technical Particulars	220 kV System	132kV System	66 kV System
a)	Rated Voltage	245 kV (rms)	145kV (rms)	72.5 kV (rms)
b)	Rated frequency	50 HZ	50HZ	50 HZ
c)	Grounding	Solidly Earthed	Solidly Earthed	Solidly Earthed
d)	Rated power frequency withstand Voltage (1min) line to earth	460 kV (rms)	275kV (rms)	170 kV (rms)
e)	Impulse withstand BIL (1.2/50/mic. Sec) Line to earth	±1050 kVp	±650 kVp	±325 kVp
f)	Rated switching impulse Voltage (Peak) line to earth	850KVp	--	--
g)	Rated short time withstand current for 1s (rms)	50 kA	31.5kA	31.5 kA
h)	Rated peak withstand current	125 kA (peak)	80 kA (peak)	80 kA (peak)
i)	Guaranteed maximum gas losses for complete installation as well as for all individual sections in %age shall be As per IEC- 62271- 203			
j)	Seismic level shall be considered as Zone- IV, as per IS-1893, Year- 2002			

The metal-enclosed gas insulated switchgear, including the operating devices, accessories and auxiliary equipment forming integral part thereof, shall be designed, manufactured, assembled and tested in accordance with the IEC-62271-203 publications including their parts and supplements as amended or revised to date.

2.0 Reference Standards

The metal-enclosed gas-insulated switchgear, including the operating devices, accessories and auxiliary equipment forming integral part thereof, shall be designed, manufactured, assembled and tested in accordance with the following International Electro-technical Commission (IEC) Publications including their parts and supplements as amended or revised to date:

IEC 62271-203	Gas Insulated metal-enclosed switchgear for rated voltages above 52KV.
IEC 60376	New sulphur hexafluoride
IEC 62271-100	High voltage alternating current Circuit breakers
IEC 60694	Common clauses for high voltage Switchgear and control-gear standards
IEC 62271-102	Alternating current disconnectors (isolators) and earthing switches.
IEC 61128	Alternating current disconnectors. Bus-transfer current switching by disconnectors.
IEC 61129	Alternating current earthing switches. Induced current switching
IEC 66044-1	Current transformers
IEC 66044-2	Voltage transformers
IEC 60137	Bushings for alternating voltages above 1000 V
IEC 60859	Cable connections for gas-insulated switchgear
IEC 60480	Guide to checking of sulphur hexafluoride taken from electrical equipment
IEC 60099-1/4	Non-linear resistor type arresters for AC systems
IEC 60439	Factory-built assemblies of low-voltage switchgear and control gear.
IEC 60427	Report on synthetic testing of high-voltage alternating-current circuit breaker.
<u>IEC 60840</u>	<u>Power cable & Accessories for 30kV to 150kV</u>
<u>IEC 62067</u>	<u>power cable & Accessories above 150kV</u>
IEEE 80(2000)	IEEE Guide for Safety in AC Substation grounding.
CIGRE-44	Earthing of GIS- an application guide.(Electra no.151,Dec'93)

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

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

3.0 Definitions

3.1 Assembly

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

3.2 Bay

Bay refers to the area occupied by one Circuit Breaker and associated equipments used to protect one feeder/line/bus coupler in double bus scheme.

3.3 Compartment

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

3.4 Enclosure

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

3.5 Manual Operations

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

3.6 Module

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

3.7 Reservoir

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

4.0 General Design & Safety Requirement

It is understood that each manufacturer has own particular GIS design concept and it is not the purpose of this specification to impose unreasonable restrictions. However, in the interest of safety, reliability and maintainability, the switchgear offered shall meet the following minimum requirements stipulated herein.

- 4.1 The GIS assembly shall consist of separate modular compartments e.g. Circuit Breaker compartment, Bus bar compartment filled with SF6 Gas and separated by gas tight partitions so as to minimize risk to human life, allow ease of maintenance and limit the effects of gas leaks failures & internal arcs etc. These compartments shall be such that maintenance on one bus- bar/compartment may be performed without de-energising the adjacent bus-bar/feeders. These compartments shall be designed to minimize the risk of damage to adjacent sections and protection of personnel in the event of a failure occurring within the compartments. Rupture diaphragms with suitable deflectors shall be provided to prevent uncontrolled bursting of pressures developing within the enclosures under worst operating conditions, thus providing controlled pressure relief in the affected compartment.
- 4.2 The workmanship shall be of the highest quality and shall conform to the latest modern practices for the manufacture of high technology machinery and electrical switchgear.
- 4.3 The switchgear, which shall be of modular design, shall have complete phase isolation. The conductors and the live parts shall be mounted on high graded epoxy resin insulators. These insulators shall be designed to have high structural strength and electrical dielectric properties and shall be shaped so as to provide uniform field distribution and to minimize the effects of particle deposition either from migration of foreign particles within the enclosures or from the by-products of SF6 breakdown under arcing conditions.
- 4.4 Gas barrier insulators and support insulators shall have the same basis of design. The support insulators shall have holes on both sides for proper flow of gas.
- 4.5 Gas barrier insulators shall be provided so as to divide the GIS into separate compartments. They shall be suitably located in order to minimize disturbance in case of leakage or dismantling. They shall be designed to withstand any internal fault thereby keeping an internal arc inside the faulty compartment. Due to safety requirement for working on this pressurized equipment, whenever the pressure of the adjacent gas compartment is reduced, it should be ensured by the bidder that adjacent compartment would remain in service with reduced pressure. The gas tight barriers shall be clearly marked on the outside of the enclosures.
- 4.6 The material and thickness of the enclosures shall be such as to withstand an internal flash over without burn through for a period of 500 ms at rated short time withstand current. The material shall be such that it has no effect of environment as well as from the by-products of SF6 breakdown under arcing condition.
- 4.7 Each section shall have plug- in or easily removable connection pieces to allow for easy replacement of any component with the minimum of disturbance to the remainder of the equipment.
- 4.8 The material used for manufacturing the switchgear equipment shall be of the type, composition and have physical properties best suited to their particular purposes and in accordance with the latest engineering practices. All the conductors shall be fabricated of aluminum/ copper tubes of cross sectional area suitable to meet the normal and short circuit current rating requirements. The finish of the conductors shall be smooth so as to prevent any electrical discharge. The conductor ends shall be silver plated and fitted into finger contacts or tulip contacts. The contacts shall be of sliding type to allow the conductors to expand or contract axially due to temperature variation without imposing any mechanical stress on supporting insulators.
- 4.9 Each pressure filled enclosure shall be designed and fabricated to comply with the requirements of the applicable pressure vessel codes and based on the design temperature and design pressures as defined in IEC-62271-203/ IEC-62271-200.
- 4.10 The manufacturer shall guarantee that the pressure loss within each individual gas-filled compartment shall not be more than half percent (0.5%) per year.
- 4.11 Each gas-filled compartment shall be equipped with static filters, density switches, filling valve and safety diaphragm. The filters shall be capable of absorbing any water vapour which may penetrate into the enclosures as well as the by-products of SF6 during interruption. Each gas

- compartment shall be fitted with separate non-return valve connectors for evacuating & filling the gas and checking the gas pressure etc.
- 4.12 The switchgear line-up when installed and operating under the ambient conditions shall perform satisfactorily and safely under all normal and fault conditions. Even repeated operations up to the permissible servicing intervals under 100% rated and fault conditions shall not diminish the performance or significantly shorten the useful life of the switchgear. Any fault caused by external reasons shall be positively confined to the originating compartment and shall not spread to other parts of the switchgear. The internal components shall be maintenance free for at least 10 years. Routine replacements of insulating gas shall not be required in intervals of less than ten years.
- 4.13 The thermal rating of all current carrying parts shall be minimum for one sec for the rated symmetrical short – circuit current.
- 4.14 The switchgear shall be of the free standing, self-supporting with easy accessibility to all the parts during installation & maintenance with all high-voltage equipment installed inside gas-insulated metallic and earthed enclosures. It shall be suitably sub-divided into individual arc and gas-proof compartments at least for :
- Bus bars
 - Intermediate compartment
 - Circuit breakers
 - Bus/Line disconnectors
 - Voltage Transformers
 - Gas Insulated bus section between GIS and XLPE cable/overhead conductor
 - Gas Insulated bus section between GIS & Transformer
- The bus enclosure should be sectionalized in a manner that maintenance work on any bus disconnector (when bus and bus disconnector are enclosed in a single enclosure) can be carried out by isolating and evacuating the small effected section and not the entire bus.
- 4.15 The arrangement of the individual switchgear bays shall be such so as to achieve optimum space- saving, neat and logical arrangement and adequate accessibility to all external components.
- 4.16 It is required that the three phases of each switchgear bay be arranged side by side. The arrangement of the equipment offered must provide adequate access for operation, testing and maintenance.
- 4.17 Local Control & Substation Automation System:-**
 Separate control cubicle including gas monitoring kiosk shall be provided for each bay which shall be installed near the switchgear for local control & monitoring of respective switchgear bay. Each LCC shall contain the local control, interlocking, operation and indication devices for the associated GIS feeder bay.
 The LCC shall be free-standing / integrated with the GIS switchgear. A general arrangement drawing showing the installation position shall be submitted with the quotation.
 Local control cubicle for GIS shall be equipped with suitable hardware & software for remote control operation and conform to the bay level controller as detailed in Section: Substation Automation System.
- 4.18 All the elements shall be accessible without removing support structures for routine inspections and possible repairs. The removal of individual enclosure parts or entire breaker bays shall be possible without disturbing the enclosures of neighboring bays.
- 4.19 It should be impossible to unwillingly touch live parts of the switchgear or to perform operations that lead to arcing faults without the use of tools or brute force.
- 4.20 In case of any repair or maintenance on one busbar, disconnectors, the other busbar/other equipments should be live and in service.
- 4.21 All interlocks that prevent potentially dangerous mal-operations shall be constructed such that they can not be operated easily, i.e. the operator must use tools or brute force to over-ride them.
- 4.22 In general the contours of energized metal parts of the GIS and any other accessory shall be such, so as to eliminate areas or points of high electrostatic flux concentrations. The surfaces shall be smooth with no projection or irregularities which may cause visible corona. No corona shall be visible in complete darkness which the equipment is subjected to specified test voltage. There shall be no radio interference from the energized switchgear at rated voltage.
- 4.23 The enclosure shall be of continuous design and shall meet the requirement as specified in

clause no. 10 (special considerations for GIS) of IEEE- 80, Year- 2000.

The enclosure shall be sized for carrying induced current equal to the rated current of the Bus. The conductor and the enclosure shall form the concentric pair with effective shielding of the field internal to the enclosure.

- 4.24 The fabricated metal enclosures shall be of Aluminium alloy having high resistance to corrosion, low electrical losses and negligible magnetic losses. All joint surfaces shall be machined and all castings shall be spot faced for all bolt heads or nuts and washers. All screws, bolts, studs and nuts shall conform to metric system. The other type of non-magnetic enclosures may be considered.
- 4.25 The breaker enclosure shall have provision for easy withdrawal of the interrupter assemblies. The removed interrupter assembly must be easily and safely accessible for inspection and possible repairs.
- 4.26 The enclosure shall be designed to practically eliminate the external electromagnetic field and thereby electrodynamic stresses even under short circuit conditions.
- 4.27 The elbows, bends, cross and T-sections of interconnections shall include the insulators bearing the conductor when the direction changes take place in order to ensure that live parts remain perfectly centered and the electrical field is not increased at such points.
- 4.28 The Average Intensity of electromagnetic field shall not be more than 50 μ Tesla. The contractor shall furnish all calculations and documents in support of the above during detailed engineering.
- 4.29 The Bidder shall furnish the following information regarding the loosely distributed metallic particles within the GIS encapsulation.
 - a) Calculations of critical field strength for specific particles of defined mass and geometry.
 - b) The methodology and all the equipment for electrical partial discharge (PD) detection and/or acoustic detection methods, including that mentioned in the specification elsewhere.
- 4.30 The switchgear shall have provision for connection with ground mat risers. This provision shall consist of grounding pads to be connected to the ground mat riser in the vicinity of the equipment.
- 4.31 The ladders and walkways shall be provided wherever necessary for access to the equipment. A portable ladder with adjustable height may also be supplied to access to the equipment.
- 4.32 Wherever required, the heaters shall be provided for the equipment in order to ensure the proper functioning of the switchgear at specified ambient temperatures. The heaters shall be rated for 230V AC supply and shall be complete with thermostat, control switches and fuses, connected as a balanced 3-phase 4-wire load. The possibility of using heaters without thermostats in order to achieve the higher reliability may be examined by the bidder and accordingly included in the offer but it shall be ensured by the bidder that the temperature rise of different enclosures where heating is provided should be within safe limits as per relevant standards. One copy of the relevant extract of standard to which the above arrangement conforms along with cost reduction in offer. If any, shall also be furnished along with the offer. The heaters shall be so arranged and protected as to create no hazard to adjacent equipment from the heat produced.
- 4.33 The enclosure & support structure shall be designed that a mechanic 1780 mm in height and 80Kg in weight is able to climb on the equipment for maintenance.
- 4.34 The sealing provided between flanges of two modules / enclosures shall be such that long term tightness is achieved.
- 4.35 Alarm circuit shall not respond to faults for momentary conditions. The following indications including those required elsewhere in the specifications shall be generally provided in the alarm and indication circuits.
- 4.35.1 Gas Insulating System:**
 - a) Loss of Gas Density.
 - b) Loss of Heater power(if required)
 - c) Any other alarm necessary to indicate deterioration of the gas insulating system.
- 4.35.2 Operating System:**
 - a) Low operating pressure
 - b) Loss of Heater power
 - c) Loss of operating power

- d) Loss of control
 - e) Pole Disordance
- 4.36 The equipment will be operated under the following ambient conditions:
- a) The ambient temperature varies between 0°C and 50°C. However, for design purposes, ambient temperature should be considered as 50°C.
 - b) The humidity will be about 95% (indoors)
 - c) The elevation is less than 1000 meters.
- 4.37 Temperature rise of current carrying parts shall be limited to the values stipulated in IEC-694, under rated current and the climatic conditions at site. The temperature rise for accessible enclosure shall not exceed 20°C above the ambient temperature of 50°C. In the case of enclosures, which are accessible but need not be touched during normal operation, the temperature rise limit may be permitted upto 30°C above the ambient of 50°C.
- 4.38 In case of any internal arc fault regardless whether it occurs in a bus bar section, a bus bar isolator or the circuit breaker, repair works should be possible without shutting down the substation; at least one busbar and the undisturbed feeder should remain in operation. It should be possible to remove and replace a fully assembled circuit breaker without interfering the operation of the adjacent feeder. All circuit breakers should be interchangeable.
- 4.39 The GIS equipments shall be arranged in such a manner that in case of maintenance works on any of the equipment, at least one bus bar should be available for operation.
- 4.40 Inter bay width shall be sufficient to allow access to all drive mechanisms and other termination boxes without the need of dismantling other apparatuses.
- These conditions shall be taken into account by the supplier in the design of the equipment.

5.0 Bellows or Compensating Units:-

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

- 1) Lateral / Vertical mounting units: These shall be inserted, as required, between sections of busbars, on transformer and XLPE cable etc. Lateral mounting shall be made possible by a sliding section of enclosure and tubular conductors.
- 2) Axial compensators: These shall be provided to accommodate changes in length of busbars due to temperature variations.
- 3) Parallel compensators: These shall be provided to accommodate large linear expansions and angle tolerances.
- 4) Tolerance compensators: These shall be provided for taking up manufacturing, site assembly and foundation tolerances.
- 5) Vibration compensators: These bellow compensators shall be provided for absorbing vibrations caused by the transformers when connected to SF6 switchgear by oil- SF6 bushings.
- 6) The electrical connections across the bellows or compensating units shall be made by means of suitable connectors.

6.0 Indication and Verification of Switch Positions

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

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

7.0 Pressure Relief Devices

Pressure relief devices shall be provided in the gas sections to protect the main gas enclosures from damage or distortion during the occurrence of abnormal pressure increase or shock waves generated by internal electrical fault arcs (preferably in downward direction). Pressure relief shall be achieved either by means of diaphragms or plugs venting directly into the atmosphere in a controlled direction.

If the pressure relief devices vent directly into the atmosphere, suitable guards and deflectors shall be provided. Contractor shall submit to the Employer the detailed criteria design regarding location of pressure relief devices/rupture diaphragms.

8.0 Pressure Vessel Requirements

The enclosure shall be designed for the mechanical and thermal loads to which it is subjected in service. The enclosure shall be manufactured and tested according to the pressure vessel code (ASME/CENELEC code for pressure Vessel.)

Each enclosure has to be tested as a routine test at 1.5 times the design pressure for one minute. The bursting strength of Aluminium castings has to be at least 5 times the design pressure. A bursting pressure test shall be carried out at 5 times the design pressure as a type test on each type of enclosure.

9.0 Circuit Breakers

General

SF6 gas insulated metal enclosed circuit breakers (for 220KV, 132kV & 66kV) shall comply with the latest revisions of IEC- 62271-100 & relevant IEC except to the extent explicitly modified in the specification and shall meet with requirements specified. Circuit breakers shall be equipped with the operating mechanism. SF6 Circuit breakers shall be of self blast / single pressure (puffer) type. Complete circuit breaker with all necessary items for successful operation shall be supplied. The circuit breakers shall be designed for high speed single and three phase reclosing with an operating sequence and timing as specified.

9.1 Duty Requirements

Circuit breaker shall be C2 – M2 – E1 class as per IEC 62271-100. Circuit breaker shall meet the duty requirements for any type of fault or fault location also for line charging and dropping when used on 220kV, 132kV & 66kV effectively grounded system and perform make and break operations as per the stipulated duty cycles satisfactorily.

9.2 The circuit breaker shall be capable of:

- i. Interrupting the steady and transient magnetizing current corresponding to 220/132/66 kV class transformers of 100 MVA ratings on 220/132/66kV side.
- ii. Interrupting line/cable charging current as per IEC without re-strikes and without use of opening resistors.
- iii. Clearing short line fault (Kilometric faults) with source impedance behind the bus equivalent to symmetrical fault current specified.
- iv. Breaking 25% the rated fault current at twice the rated voltage under phase opposition condition.
- v. The breaker shall satisfactorily withstand the high stresses imposed on them during fault clearing, load rejection and re-energisation of lines with trapped charges.

9.3 Total Break Time

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

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

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

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

9.4 Constructional Features

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

9.4.1 Contacts

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

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

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

ambient conditions.

- 9.4.4 For C.B's, the gap between the open contacts shall be such that it can withstand atleast the rated phase to ground voltage for eight hours at zero pressure above atmospheric level of SF6 gas due to its leakage. The breaker should be able to withstand all dielectric stresses imposed on it in open condition at lockout pressure continuously (i.e. 2 pu power frequency voltage across the breaker continuously)
- 9.4.5 For C.B's In the interrupter assembly there shall be an adsorbing product box to minimize the effect of SF6 decomposition products and moisture. The material used in the construction of the circuit breakers shall be such as to be fully compatible with SF6 gas decomposition products.
- 9.4.6 Provisions shall be made for attaching an operational analyzer to record travel, speed and making measurement of operating timings etc. after installation at site.
- 9.4.7 Static Contact Resistance Meter and Dynamic Contact Resistance Meter shall also be provided along with CB operational analyzer.

9.5 Operating Mechanism

9.5.1 General Requirements:

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

9.5.2 Control

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

If additional elements are introduced in the trip coil circuit their successful operation and reliability for similar applications on circuit breakers shall be clearly brought out in the additional information schedules. In the absence of adequate details the offer is likely to be rejected.

- f) Density meter contacts and pressure switch contacts shall be suitable for direct use as permissive in closing and tripping circuits. Separate contacts have to be used for each of tripping and closing circuits. If contacts are not suitably rated and multiplying relays are used then fail safe logic/schemes are to be employed. DC supplies for all auxiliary circuit shall be monitored and for remote annunciations and operation lockout in case of dc failures.
- g) The auxiliary switch of the breaker shall be positively driven by the breaker operating rod.

9.5.3 Spring operated Mechanism

- a) Spring operated mechanism shall be complete with motor in accordance with Section GTR. Opening spring and closing spring with limit switch for automatic charging and other necessary accessories to make the mechanism a complete operating unit shall also be provided.
- b) As long as power is available to the motor, a continuous sequence of the closing and opening operations shall be possible. The motor shall have adequate thermal rating for this duty.
- c) After failure of power supply to the motor one close open operation shall be possible with the energy contained in the operating mechanism.
- d) Breaker operation shall be independent of the motor which shall be used solely for compressing the closing spring. Facility for manual charging of the closing spring shall also be provided. The motor rating shall be such that it required preferably not more than 60 seconds for full charging of the closing spring.
- e) Closing action of circuit breaker shall compress the opening spring ready for tripping.
- f) When closing springs are discharged after closing a breaker, closing springs shall automatically be charged for the next operation and an indication of this shall be provided in the local and remote control cabinet.
- g) Provisions shall be made to prevent a closing operation of the breaker when the spring is in the partial charged condition.
- h) Mechanical interlocks shall be provided in the operating mechanism to prevent discharging of closing springs when the breaker is in the closed position.
- i) The spring operating mechanism shall have adequate energy stored in the operating spring to close and latch the circuit breaker against the rated making current and also to provide the required energy for the tripping mechanism in case the tripping energy is derived from the operating mechanism.

9.5.4 Hydraulically Operated Mechanism :

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

9.6 Additional Data To Be Furnished Alongwith The Offer or during detailed engineering after receipt of order:

- a) Drawing showing contacts in close, arc initiation, full arcing, arc extinction and open position.

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

9.7 Technical Parameters - Circuit Breaker

S.No.	Technical Particulars	220 kV System	132kV System	66 kV System
a)	Rated voltage kV (rms)	245	145	72.5
b)	Rated frequency (Hz)	50	50	50
c)	No. of poles	3	3	3
d)	Type of circuit breaker	SF6 insulated	SF6 insulated	SF6 insulated
e)	Rated continuous current (A) at an ambient temperature of 50° C	2000 A for bus coupler 1250A for other bay module	2000 A for bus coupler 1250A for other bay module	2000A
f)	Rated short circuit capacity	50 kA with %age of DC component as per IEC- 62271-100 corresponding to minimum opening conditions as specified.	31.5 kA with %age of DC component as per IEC- 62271- 100 corresponding to minimum opening conditions as specified.	31.5 kA with %age of DC component as per IEC- 62271- 100 correspondig to minimum opening conditions as specified.
g)	Symmetrical interrupting capability kA (rms)	50	31.5	31.5
h)	Rated short circuit making current kAp	125	80	80
i)	Short time current carrying capability for one second kA(rms)	50	31.5	31.5
j)	Rated line charging interrupting current at 90 deg. Leading power factor angle(A rms) (The breaker shall be able to interrupt the rated line charging current with test voltage immediately before opening equal to the product of $U/\sqrt{3}$ and 1.4 as per IEC- 62271-100)	As per IEC	As per IEC	As per IEC
k)	First pole to clear factor	As per IEC	As per IEC	As per IEC
l)	Total break time (ms)	65	65	65
m)	Total closing time (ms)	100	65	65
n)	Rated operating duty cycle	O-0.3s-CO-3 min-CO	O-0.3s-CO-3 min-CO	O-0.3s-CO-3 min-CO
o)	Rated insulation levels			
i)	Full wave impulse with stand voltage (1.2/50 μ sec.)			
	- between line terminals and ground	± 1050 kVp	± 650 kVp	± 325 kVp
	- between terminals with	± 1200 kVp	± 750 kVp	± 375 kVp

	circuit breaker open			
ii)	One minute power frequency withstand voltage - between line terminals and ground	As per IEC	As per IEC	As per IEC
	- between terminals with circuit breaker open	As per IEC	As per IEC	As per IEC
p)	Max. radio interference voltage for frequency between 0.5 MHz and 2 MHz	< 1000 Micro volts (at 156 kV rms)	< 500 Micro volts (at 92 kV rms)	< 500 Micro volts (at 92 kV rms)
q)	Max. difference in the instants of closing/opening of contacts (ms) between poles	As per IEC	As per IEC	As per IEC
r)	Trip coil and closing coil voltage	220V DC with variation as specified in Sec. GTR	220V DC with variation as specified in Sec. GTR	220V DC with variation as specified in Sec. GTR
s)	Auxiliary Contacts Auxiliary switch shall also comply with requirements as given. Independent single pole reversible contacts (from NO to NC & vice versa)	Each CB pole shall be provided with an auxiliary switch with 20% of spare - NO and 20% spare NC contact for use in future with due provision to add more if required.	Each CB pole shall be provided with an auxiliary switch with 20% of spare - NO and 20% spare NC contact for use in future with due provision to add more if required.	Each CB pole shall be provided with an auxiliary switch with 20% of spare - NO and 20% spare NC contact for use in future with due provision to add more if required.
i)	Rating of Auxiliary contacts	10A at 220 V DC	10A at 220 V DC	10A at 220 V DC
ii)	Breaking capacity of Aux. Contacts.	2A DC with the circuit time constant of not less than 20 ms	2A DC with the circuit time constant of not less than 20 ms	2A DC with the circuit time constant of not less than 20 ms
t)	System neutral earthing	Solidly Earthed	Solidly Earthed	Solidly Earthed

10.0 Disconnectors (Isolators)

10.1 General

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

Technical Parameter

S. No	Particulars	220 kV	132kV	66kV
a)	Rated voltage (rms) Un	245kV	145 kV	72.5 kV
b)	Rated frequency	50 Hz	50 Hz	50 Hz
c)	System earthing	Solidly Earthed	Solidly Earthed	Solidly Earthed
d)	Type	SF6 insulated	SF6 insulated	SF6 insulated
e)	Rated continuous current (A) at 50° C ambient temp.	2000 A for bus coupler	2000 A for bus coupler	2000 A

		1250A for other bay module	1250A for other bay module	
f)	Rated short time withstand current of isolator and earth switch	50 kA for 1 Sec	31.5 kA for 1 Sec	31.5 kA for 1 Sec
g)	Rated dynamic short circuit withstand current withstand current of isolator and earth switch	125 kAp	80 kAp	80 kAp
h)	Rated insulation level: One minute power freq. Withstand voltage: To earth : Across isolating distance	As per IEC As per IEC	As per IEC As per IEC	As per IEC As per IEC
i)	Rated insulation levels; 1.2/50 μ sec. Lighting impulse withstand voltage (+ve or -ve polarity) To earth: Across isolating distance	± 1050 kVp ± 1200 kVp	± 650 kVp ± 750 kVp	± 325 kVp ± 375 kVp
j)	Rated mechanical terminal load	As per IEC	As per IEC	As per IEC
k)	No. of spare auxiliary contacts on each isolator	6 NO and 6 NC	6 NO and 6NC	6 NO and 6NC
l)	No. of spare auxiliary contacts on each earthing switch	6 NO and 6 NC	6 NO and 6NC	6 NO and 6NC
m)	Max. radio interference voltage for frequency between 0.5MHz and 2MHz	< 1000 Micro volts (at 156 kV rms)	< 500 Micro volts (at 92 kV rms)	< 500 Micro volts (at 92 kV rms)

10.2 Construction & Design

- 10.2.1 The three pole group operated / common operating mechanism disconnectors shall be operated by electric motor suitable for use on 220V DC system and shall be equipped with a manual operating mechanism for emergency use. The motor shall be protected against over current and short circuit.
- 10.2.2 Disconnectors shall be designed as per relevant IEC. These shall be suitable to make and break the charging currents during their opening and closing. They shall also be able to make and break loop current which appears during transfer between bus bars. The contact shielding shall also be designed to prevent restrikes and high local stresses caused by transient recovery voltages when these currents are interrupted.
- 10.2.3 The disconnecting switches shall be arranged in such a way that all the three phases operate simultaneously. All the parts of the operating mechanism shall be able to withstand starting torque of the motor mechanism without damage until the motor overload protection operates.
- 10.2.4 It shall be possible to operate the disconnecting switches manually by cranks or handwheels. The contacts shall be both mechanically and electrically disconnected during the manual operation.
- 10.2.5 The operating mechanisms shall be complete with all necessary linkages, clamps, couplings, operating rods, support brackets and grounding devices. All the bearings shall be permanently lubricated or shall be of such a type that no lubrication or maintenance is required.
- 10.2.6 The opening and closing of the disconnectors shall be achieved by either local or remote control. The local operation shall be by means of a two-position control switch located in the bay module control cabinet.
- 10.2.7 Remote control of the disconnectors from the control room shall be made by means of remote/local transfer switch.
- 10.2.8 The disconnector operations shall be inter-locked electrically with the associated circuit breakers in such a way that the disconnector control is inoperative if the circuit breaker is closed.
- 10.2.9 Each disconnector shall be supplied with auxiliary switch having six normally open and six normally closed contacts for future use and provision shall be made to add more if required over and above those required for switchgear interlocking and automation purposes. The auxiliary switch contacts are to be continuously adjustable such that, when required, they can

be adjusted to make contact before the main switch contacts.

- 10.2.10 The signaling of the closed position of the disconnecter shall not take place unless it is certain that the movable contacts will reach a position in which the rated normal current, peak withstand current and short-time withstand current can be carried safely.
- 10.2.11 The signaling of the open position of the disconnecter shall not take place unless the movable contacts have reached such a position that the clearance between the contacts is at least 80 percent of the rated isolating distance.
- 10.2.12 All auxiliary switches and auxiliary circuits shall be capable of carrying a current of at least 10 A DC continuously.
- 10.2.13 The auxiliary switches shall be capable of breaking at least 2A in a 220V DC circuit with a time constant of not less than 20 milliseconds.
- 10.2.14 The disconnectors and safety grounding switches shall have a mechanical key (pad locking key) and electrical inter-locks to prevent closing of the grounding switches when isolator switches are in the closed position and to prevent closing of the disconnectors when the grounding switch is in the closed position.
- 10.2.15 The local control of the Isolator and high-speed grounding switches from the bay module control panel should be achieved from the individual control switches with the remote/local transfer switch set to local.
- 10.2.16 All electrical sequence interlocks will apply in both remote and local control modes.
- 10.2.17 Each disconnecter shall have a clearly identifiable local, positively driven mechanical position indicator, together with position indicator on the bay module control cabinet and provisions for taking the signals to the control room. The details of the inscriptions and colouring for the indicator are given as under :

	SIGN	COLOUR
Open position	Open or 'O'	Green
Closed position	Closed or 'I'	Red

- 10.2.18 All the disconnecting switches shall have arrangement allowing easy visual inspection of the travel of the switch contacts in both open and close positions, from the outside of the enclosure.
- 10.2.19 The disconnecting switches shall be provided with rating plates and shall be accessible for inspection.
- 10.2.20 The disconnecting switches shall be capable of being padlocked in both the open and closed positions with the operating motor automatically disengaged. The padlocking device shall be suitable for a standard size lock with a 10 mm shank. The padlock must be visible and directly lock the final output shaft of the operating mechanism. Integrally mounted lock when provided shall be equipped with a unique key for such three phase group. Master key is not permitted.

11.0 Safety Grounding Switches

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

	SIGN	COLOUR
Open position	Open or 'O'	Green
Closed position	Closed or 'I'	Red

- 11.5 Interlocks shall be provided so that manual operation of the switches or insertion of the manual operating device will disable the electrical control circuits.
- 11.6 Each ground switch shall be fitted with auxiliary switches having six normally open and six normally closed contacts for use by others & provision shall also be made to add more if required in future, over and above those required for local interlocking and position indication purposes.

- 11.7 Provision shall be made for padlocking the ground switches in either the open or closed position.
- 11.8 All portions of the grounding switch and operating mechanism required for grounding shall be connected together utilizing flexible copper conductors having a minimum cross-sectional area of 50 sq. mm.
- 11.9 The main grounding connections on each grounding switch shall be rated to carry the full short circuit rating of the switch for 1 sec. and shall be equipped with a silver - plated terminal connector suitable for steel strap of adequate rating for connection to the grounding grid.
- 11.10 The safety grounding switches shall conform to the requirements of IEC - 62271- 102
- 11.11 Mechanical position indication shall be provided locally at each switch and remotely at each bay module control cabinet/ substation automation system.
- 11.12 The rated Induced Current and Voltage for earth switches for both electrostatic and electromagnetic coupling shall be as per IEC 62271-102.
- 12.0 High Speed Make Proof Grounding Switches**
- 12.1 Grounding switches located at the beginning of the feeder bay modules shall be of the high speed, make proof type and will be used to discharge the respective charging currents, in addition to their safety grounding function. These grounding switches shall be capable of interrupting the inductive currents and to withstand the associated TRV.
- 12.2 Single phase switches shall be provided with operating mechanism suitable for operation from a 220V DC.
- 12.3 The switches shall be fitted with a stored energy closing system to provide fault making capacity.
- 12.4 The short circuit making current rating of each ground switch shall be at least equal to its peak withstand current rating. The switches shall have inductive/ capacitive current switching capacity as per IEC-62271-102.
- 12.5 Each high speed make proof grounding switch shall have clearly identifiable local positive driven mechanical indicator together with position indicator on the bay module control cabinet and provision for taking the signal Control Room.
- 12.6 The details of the inscription and colouring for the indicator shall be as under:-
- | | SIGN | COLOUR |
|------------------------|---------------|---------------|
| Open position | Open or 'O' | Green |
| Closed position | Closed or 'I' | Red |
- 12.7 High speed ground switch operation should be possible locally from the bay module control cabinet, or remotely from the control room in conjunction with opening of the associated disconnector.
- 12.8 These high speed grounding switches shall be electrically interlocked with their associated circuit breakers and disconnectors so that the grounding switches can not be closed if the circuit breakers and disconnectors are closed.
- 12.9 Interlocks shall be provided so that the insertion of the manual operating devices will disable the electrical control circuits.
- 12.10 Each high speed ground switch shall be fitted with auxiliary switches having six NO & six NC auxiliary contacts for use by others & provision shall also be made to add more if required in future, over and above these required for local interlocking and position indication. All contacts shall be wired to terminal blocks in the local bay control cabinet. Provision shall be made for padlocking the ground switches in their open or closed position.
- 12.11 All portion of the grounding switches and operating mechanism required for connection to ground shall be connected together utilizing copper conductor having minimum cross-sectional area of 100 sq. mm.
- 12.12 The main grounding connection on each grounding switch shall be rated to carry the short time withstand current rating of the switch for 1 sec. and shall be equipped with a silver plated terminal connector suitable for steel strap of adequate design for connection to the grounding grid.
- 12.13 The high speed make proof grounding switches shall confirm to the requirements of IEC- 62271-102.
- 12.14 The rated Induced Current and Voltage for earth switches for both electrostatic and electromagnetic coupling shall be as per IEC 62271-102.

13.0 Instrument Transformers

13.1 Current Transformers

A) General:

- i. The current transformers and accessories shall conform to IEC: 60044-1 and other relevant standards except to the extent explicitly modified in the specification.
- ii. The Principle parameters shall be as per clause 13.4.1.

B) Ratios and Characteristics

The number, rating, ratios, accuracy class, etc. for the individual current transformers secondary cores shall be in accordance with Table I – A , II – A , I – B , II-B, III – B, IV-B, I-C & II-C.

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

C) Rating and Diagram Plates

Rating and diagram plates shall be as specified in the IEC specification incorporating the PO No, Date and year of manufacture. The general knee point voltage formula and rated continuous thermal current shall also be marked on the name plate.

The diagram plates shall show the terminal markings and the relative physical arrangement of the current transformer cores with respect to the primary terminals (P1 & P2).

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

D) Constructional Details:

- a) The current transformers incorporated into the GIS will be used for protective relaying and metering and shall be of metal- enclosed type. All the current transformers shall have effective electromagnetic shields to protect against high frequency transients.
- b) Each current transformer shall be equipped with a marshalling box with terminals for the secondary circuits, which are connected to the local control cubicle. The star/delta configuration and the inter connection to the protection panels will be done at the CT terminal block located in the local control cubicle.
- c) Current transformers guaranteed burdens and accuracy class are to be intended as simultaneous for all cores.
- d) The rated extended primary current shall be 125% at all ratios.
- e) The instrument security factor at all ratios shall be as I – A , II – A , I – B , II-B, III – B, IV-B, I-C & II-C for metering cores wherever aux CT's/Reactors are allowed in the CT's then all parameters specified shall have to be met treating auxiliary CT's as an integral part of the CT's. The aux CT's/Reactors shall preferably be built in construction of the CT's.
- f) The wiring diagram, for the interconnections of the three single phase CTs shall be provided inside the marshalling box.
- g) The 220kV line and bus coupler current transformers shall be suitable for high speed auto-reclosing.
- h) Provisions shall be made for primary injection testing either within CT or outside.
- i) Electromagnetic shields to be provided against high frequency transients typically 1-30 MHz.

13.2 Voltage Transformers

A) General

The voltage transformers shall conform to IEC- 60044-2 and other relevant standards except to the extent explicitly modified in the specification.

Voltage transformers shall be of the electromagnetic type with SF6 gas insulation. The earth end of the high voltage winding and the ends of the secondary winding shall be brought out in the terminal box. The Principle parameters shall be as per clause 13.4.2.

B) Ratios and Characteristics

The rating, ratio, accuracy class, connection etc. for the voltage transformers shall be in accordance with Table III – A, V-B & III– C .

C) Rating and diagram plates

Rating and diagram plate shall be provided complying with the requirements of the IEC specification incorporating the PO No., Date and year of manufacture and including turns ratio, voltage ratio, burden, connection diagram, rated continuous and short time voltage factor etc.

D) Secondary Terminals, Earthing and Fuses/MCBs

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

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

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

F) Constructional Details of Voltage Transformers:

- a) The voltage transformers shall be located in a separate bay module on the bus and will be connected phase to ground and shall be used for protection, metering and synchronization.
- b) The voltage transformers shall be of inductive type, nonresistant and shall be contained in their own-SF6 compartment, separated from other parts of installation. The voltage transformers shall be effectively shielded against high frequency electromagnetic transients.
- c) Voltage transformer's secondary shall be protected by HRC cartridge type fuses/MCBs for all the windings. In addition fuses/MCBs shall be provided for the protection and metering windings for fuse monitoring scheme. The secondary terminals of the VT's shall be terminated to the stud type non-disconnecting terminal blocks in the secondary boxes via the fuse/MCB.
- d) The voltage transformer should be thermally and dielectrically safe when the secondary terminals are loaded with the guaranteed thermal burdens.
- e) The diagram for the interconnection of the VTs shall be provided inside the marshalling box.

13.3 Tests

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

13.4 Principle Parameters:

13.4.1 Current Transformers

S. No	Particulars	220 kV	132 kV	66kV
a)	Rated voltage Un	245kV (rms)	145kV (rms)	72.5kV (rms)
b)	Rated frequency	50 Hz	50 Hz	50 Hz
c)	System neutral earthing	Solidly Earthed	Solidly Earthed	Solidly Earthed
d)	Rated short time thermal current	50 kA for 1 second	31.5 kA for 1 second	31.5 kA for 1 second
e)	Rated dynamic current	125 kAp	80 kAp	80 kAp
f)	Rated insulation levels			
	i)1.2/50 micro second impulse voltage	±1050 kVp	±650 kVp	±325 kVp
	ii)1 Minute power frequency withstand voltage	460 kV (rms)	275 kV (rms)	170 kV (rms)
g)	One minute power frequency withstand voltage between secondary terminal & earth	5kV (rms)	5kV (rms)	5kV (rms)
h)	Maximum temperature rise over an ambient temperature of 50° C	As per IEC 60044-1	As per IEC 60044-1	As per IEC 60044-1
i)	Radio interference voltage at 1.1 Un/√3 and frequency range 0.5 to 2 MHz	< 1000 Micro volts	< 500 Micro volts	< 500 Micro volts
j)	Partial discharge level as per IEC	≤10 pico coulomb	≤10 pico coulomb	≤10 pico coulomb
k)	Rated continuous thermal current	125% on all taps	125% on all taps	125% on all taps

13.4.2 Voltage Transformers

S. No	Particulars	220 kV	132kV	66kV
a)	Rated voltage U_n	245kV (rms)	145kV (rms)	72.5kV (rms)
b)	Rated frequency	50 Hz	50 Hz	50 Hz
c)	System neutral earthing	Solidly Earthed	Solidly Earthed	Solidly Earthed
d)	System fault level (for 1 second)	50 kA	31.5 kA	31.5 kA
e)	Rated insulation levels			
	i)1.2/50 micro second impulse voltage	± 1050 kVp	± 650 kVp	± 325 kVp
	ii)1 Minute power frequency withstand voltage	460 kV (rms)	275 kV (rms)	170 kV (rms)
f)	One minute power frequency withstand voltage between secondary terminal & earth	3kV (rms)	3kV (rms)	3kV (rms)
g)	Radio interference voltage at 1.1 $U_n/\sqrt{3}$ and frequency range 0.5 to 2 MHz	< 1000 μ V	< 500 μ V	< 500 μ V
h)	Rated voltage factor	1.2 continuous & 1.5 for 30secs	1.2 continuous & 1.5 for 30secs	1.2 continuous & 1.5 for 30secs
i)	Partial discharge level as per IEC(pico coulomb)	≤ 10 pC	≤ 10 pC	≤ 10 pC
j)	Maximum temperature rise over an ambient temperature of 50° C	As per IEC 60044-2	As per IEC 60044-2	As per IEC 60044-2

14.0 Surge Arrestors

The surge arrestors shall conform in general to latest IEC – 60099 – 4. The technical specification of the surge arrestor is placed separately.

14.1 INSULATION CO-ORDINATION AND SELECTION OF SURGE ARRESTOR

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

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

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

15.0 Seismic Design Criteria:

The equipment shall be designed for operation in seismic zone for earthquake resistance. The seismic loads are due to the horizontal and vertical acceleration which may be assumed to act non concurrently. Seismic level Zone- IV, as per new IS- 1893, Year-2002 has to be considered for the design of equipment. The seismic loads shall be equal to static loads corresponding to the weight of the parts multiplied by the acceleration. The equipments along with its parts shall be strong enough and sufficiently well connected to resist total operating stresses resulting from the forces in normal operation but in case of abnormal condition shall also resist with forces superimposed due to earthquakes. The copies of type test reports for similar rated equipment, if tested earlier, should be furnished along with the tender. If the equipment has not been type tested earlier, design calculations of simulated parameters should be furnished along with the offer.

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

16.0 Quality of SF6 Gas

- a) The SF6 gas insulated metal-clad switchgear shall be designed for use with SF6 gas complying with the recommendations of IEC 376, 376A & 376B, at the time of the first charging with gas. All SF6 gas supplied as part of the contract shall comply with the requirements of IEC as above as a minimum & should be suitable in all respects for use in the switchgear under all operating conditions.
- b) The high pressure cylinders in which SF6 gas is supplied & stored at site shall comply with the requirements of following standards & regulations:
IS: 4379 Identification of the contents of industrial gas cylinders.
IS : 7311 Seamless high carbon steel cylinders for permanent & high pressure liquefiable gases. The cylinders shall also meet Indian Boilers Regulations. (Mandatory)
- c) Test
SF6 gas shall be tested for purity, dew point, air, hydrolysable fluorides and water contents as per IEC: 376, 376A & 376B and test certificates shall be furnished to the Employer indicating all test results as per IEC standards for each lot of SF6 gas. Further site tests for moisture, air con-tent, flash point and dielectric strength to be done during commissioning of GIS. Gas bottles should be tested for leakage during receipt at site.
- d) The successful bidder after award of contract shall indicate diagnostic test methods for checking the quality of gas in the various sections during service. The method proposed shall, as a minimum check the moisture content & the percentage of purity of the gas on annual basis.
- e) The successful bidder after award of contract shall also indicate clearly the precise procedure to be adopted by maintenance personnel for handling equipment that are exposed to the products of arcing in SF6 Gas so as to ensure that they are not affected by possible irritants of the skin and respiratory system. Recommendations shall be submitted for suitable protective clothing, method of disposal of cleaning utensils and other relevant matters.
- f) The successful bidder after award of contract shall also indicate the details and type of filters used in various gas sections, and should also submit the operating experience with such filters.

17.0 SF6 Gas Monitoring Devices and Alarm Circuits

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

Compartments except circuit breaker

- a) Gas Refill level

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

b) 'Zone Trip' level

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

Circuit Breakers

a) 'Gas Refill' level

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

b) 'Breaker Block' level

This is the minimum gas density at which the manufacturer will guarantee the rated fault interrupting capability of the breaker. At this level the breaker block contact shall operate & the trip-ping & closing circuit shall be blocked.

c) 'Zone Trip' level

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

The bidder should furnish temperature v/s pressure curves for each setting of density monitor along with details of the monitoring device.

It shall be possible to test all gas monitoring relays/devices without de-energizing the primary equipment & without reducing pressure in the main section. Plugs & sockets shall be used for test purposes. It shall also damp the pressure pulsation while filling the gas in service, so that flickering of the pressure switch contacts does not take place.

17.2 a) Gas Leakage

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

b) **Gas Supply**

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

18.0 Painting of Enclosure

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

19.0 Heaters

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

20.0 Identification & Rating Plate

Each bay shall have a nameplate showing

a) A listing of the basic equipment from air entrance bushing to air entrance bushing (such as a breaker, disconnectors grounding switches, current transformers, voltage transformers, and bushings).

b) A schematic diagram indicating their relative locations.

c) HVPNL Contract Number.

Each module will have its own Identification & rating plate.

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

21 Tests

21.1 Type Test:

In accordance with the requirements shall conform to the type tests as per IEC-62271. The type test reports shall be considered valid irrespective of the validity of their time period

provided no major change has been introduced in the basic design technology/ functionalities of the equipment /performance characteristics/ manufacturing process

21.2 Routine Tests

Routine tests as per IEC: 62271 shall be performed.

In addition to the mechanical and electrical tests specified by IEC, the following shall also be performed.

Speed curves for each breaker shall be obtained with the help of a suitable operation analyzer to determine the breaker contact movement during opening, closing, auto-reclosing and trip free operation under normal as well as limiting operating conditions (control voltage, pneumatic pressure etc.). The tests shall show the speed of contacts directly at various stages of operation, travel of contacts, opening time, closing time, shortest time between separation and meeting of contacts at break make operation etc. This test shall also be performed at site for which the necessary operation analyzer along with necessary transducers, cables, console etc. shall be furnished as mandatory maintenance equipment.

The test for getting signature of the dynamic contact resistance measurement shall also be carried out at factory. The test result shall be treated as reference signature for condition monitoring in future.

22.0 TRANSPORT OF EQUIPMENT TO SITE.

The contractor shall be responsible for the loading, transport, handling and offloading of all equipment and materials from the place of manufacture or supply to site. The contractor shall be responsible to select and verify the route, mode of transportation and make all necessary arrangement with the appropriate authorities as well as determining any transport restrictions and regulations imposed by the government and other local authorities. All transport packages containing critical units viz Circuit breakers, disconnectors, earth switches, surge arrestors and bus sections exceeding 3 meters length shall be provided with sufficient number of electronic impact recorders (on returnable basis) during transportation to measure the magnitude and duration of the impact in all three directions. The acceptance criteria and limits of impact in all three directions which can be withstood by the equipment during transportation and handling shall be submitted by the contractor during detailed engineering. The recording shall commence in the factory and must continue till the units reach site. The data of electronic impact recorders shall be downloaded at site and a soft copy of it shall be handed over to Engineer – in –charge. Further, within three weeks the contractor shall communicate the interpretation of the data.

23.0 PACKING, STORAGE AND UNPACKING.

All the equipment shall be carefully packed for transport by sea, rail and road in such a manner that it is protected against the climatic conditions and the variations in such conditions that will be encountered enroute from the manufacturer's works to the site.

The SF6 metal clad equipment shall be shipped in the largest factory assembled units that the transport and loading limitations and handling facilities on site will allow to reduce the erection and installation work on site to a minimum.

Where possible all items of equipment or factory assembled units shall be boxed in substantial crates or containers to facilitate handling in a safe and secure manner. Should the units be considered too large for packing in crates, they shall be suitably lagged and protected to prevent damage to any part, particularly small projections, during transport and handling. Special lugs or protective supports shall be provided for lifting to prevent slings and other lifting equipment from causing damage. Each crate, container or shipping unit shall be marked clearly on the outside to show where the weight is bearing and the correct position for the slings.

Each individual piece to be shipped, whether crate, container or large unit, shall be marked with a notation of the part or parts contained therein.

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

which sections will be filled prior to shipment and the minimum allowable pressure during shipment shall be advised prior to dispatch.

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

Valves and other gas couplings associated with the switchgear gas systems shall be adequately protected against damage from any bumps or physical blows. They shall also be capped to prevent ingress of dirt or moisture or damage to any coupling, pipes, threads or special fittings. Any explosion vents and other pressure relief devices shall be suitably sealed and protected to prevent accidental exposure of the sealed sections during shipment to site. For bus ducts involving male and female joints of the current carrying conductor, the same shall be transported in disassembled condition to avoid any damage during transit. All bright parts liable to rust shall receive a coat of anti rusting composition and shall be suitably protected.

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

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

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

24. **Grounding**

The grounding system shall be designed and provided as per IEEE-80-2000 and CIGRE-44 to protect operating staff against any hazardous touch voltages and electro-magnetic interferences. As the area involved is small, contractor has to take special measures for the same.

The GIS supplier shall define clearly what constitutes the main grounding bus of the GIS. The GIS supplier must supply the entire material for grounding bus of GIS viz. conductor, clamps, joints, operating and safety platforms etc. The GIS supplier is also required to supply all the earthing conductors and associated hardware material for the following:

- 1) Connecting all GIS equipment, enclosures, control cabinets, supporting structure etc. to the ground bus of GIS.
- 2) Grounding of transformer and other outdoor switchyard equipments/ structures etc.

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

Each marshalling box, local control panel, power and control cable sheaths and other non

current carrying metallic structures shall be connected to the grounding system of GIS via connections that are separated from GIS enclosures.

The grounding connector shall be of sufficient mechanical strength to withstand electromagnetic forces as well as capable of carrying the anticipated maximum fault current without overheating. At least two grounding paths shall be provided to connect each point to the main grounding bus. Necessary precautions should be under taken to prevent excessive currents from being induced into adjacent frames, structures of reinforcing steel and to avoid establishment of current loops via other station equipment.

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

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

The bidders shall provide lightening mast/GS shield wire at suitable place for protection of whole sub-station including transformers, GIS cum control room building etc. The bidder shall submit detailed proposal for grounding system of whole substation including indoor and outdoor equipments with earthmat using 40mm diameter MS rod for approval of purchaser. The risers shall be GS flat of size 75X12mm above ground level.

The bidder shall submit detailed proposal for grounding system for approval of purchaser. Any provision to be made in the building design to take care of earthing requirement shall also be clearly spelt-out.

25.0 220 kV, 132kV & 66 kV GIS BUILDING :

- a) The buildings shall house 220 KV, 132kV and 66 KV Gas Insulated Switchgear (GIS) separately and other associated equipments inside in each of the GIS building.
- b) The bidder shall submit the design & construction proposal of the building along with necessary information, data, and drawings in the techno- commercial bid according to the complete requirements.
- c) The plot plan of floor for 220 KV, 132kV and 66 KV GIS building is enclosed. The dimension given is for reference only and may vary according to requirement of the equipment to be installed inside. The bidder shall finalize the dimensions according to the equipment offered by them providing enough space & access for erection, operation and maintenance.

GIS Accessories

26.0 Gas Filling and Evacuating Plant

All the plant necessary for filling and evacuating the SF6 gas in the switchgear shall be supplied with the contract to enable any maintenance work to be carried out. This shall include all the necessary gas cylinders for temporarily storing the evacuated SF6 gas. The capacity of the temporary storage facilities shall at least be sufficient for storing the maximum quantity of gas that could be removed when carrying out maintenance or repair work on the switchgear and associate equipment of at least one complete bay.

Where any item of the filling and evacuating plant is of such a weight that it cannot easily be carried by maintenance personnel, it shall be provided with lifting hooks for lifting and moving with the overhead cranes.

The minimum capacity of evacuation plant will be as under :

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

Compressor: 15 M3/Hour(Delivery)

The capacity of the plant should be such that it is capable of excavation/ filling of maximum quantity of gas contained in a compartment could be removed/ filled within 30 minutes while carrying out maintenance/ repair work.

The evacuation equipment shall be provided with all the necessary pipes, couplings, flexible tubes and valves for coupling up to the switchgear for filling or evacuating all the gases.

The gas compartments shall preferably be fitted with permanent non-return valves through which the gas is pumped into or evacuated form the compartments.

Details of the filling and evacuating plant that will be supplied, as well as the description of the

filling and evacuating procedures shall be provided along with the bid.

27.0 Outdoor Termination Kit:

A) General

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

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

Bushings/terminatin kit shall generally be in accordance with the requirements of IEC publication 60137/60840/62271-209 as applicable.

B) Insulation levels and creepage distances

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

The creepage distance over the external surface of outdoor bushings shall not be less than 25 mm/kV.

C) Bushing types and fitting

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

D) Mechanical forces on bushing terminals

Outdoor bushings must be capable of withstanding cantilever forces due to weight of conductor, wind force and short circuit forces etc. Design calculations in support of the cantilever strength chosen shall be submitted for Employers review and approval.

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

S. No	Particulars	220 kV	132kV	66kV
a)	Rated voltage (kV)	245kV	145kV	72.5kV
b)	Rated current	1250A	1250A	2000A
c)	Lightning impulse withstand voltage (kVp)	1050	650	325
d)	One minute power frequency withstand voltage kV (rms)	460	275	170
e)	Minimum total creepage distances (mm)	6125	3625	1815

28.0 SF6 GIS to XLPE Cable Termination :

The underground XLPE cables are to be connected to GIS by the interfacing of XLPE cable sealing end to GIS Cable termination enclosure for making connection (as applicable) XLPE cables. This interface section shall be designed in a manner which will allow ease of operation and maintenance.

The SF6 GIS to XLPE cable termination shall conform to IEC-62271-209 (latest edition). The provision shall be made for a removable link. The gap created when the link is removed should have sufficient electric strength to withstand the switchgear high voltage site tests. The bidder may suggest alternative arrangements to meet these requirements. The corona rings/stress shields for the control of electrical field in the vicinity of the isolation gap shall be provided by the GIS manufacturer.

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

The opening for access shall be provided in each phase terminal enclosures as necessary to permit removal of connectors to isolate the XLPE cables to allow carrying out the insulation tests. The typical arrangement drawing of interconnecting cables from GIS bay module to XLPE cable termination end shall be submitted along with offer.

29.0 Electric Overhead Crane :

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

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

EOT crane lifting capacity shall be adequate to handle the heaviest package of GIS but shall not be less than 10 tonnes for 220kV GIS and shall not less than 5Tfor 132kV & 66kV GIS.

30.0 Partial Discharge Monitoring System & Dew Point Meter etc

Static Contact Resistance Meter and Dynamic Contact Resistance Meter, CB operational Analyzer, SF6 Gas Detector Meter, Portable P.D meter & Dew point meter shall be offered as per relevant schedule of BPS and shall be considered for evaluation of bid. The specifications are ***enclosed at Annexure A.***

TABLE I – A
COREWISE DETAILS OF 245kV Transformer CTs
(450-300/0.577-1-1-1-1A) NUMBER OF CORES - 5

Core No.	Application	Current Ratio (A)	Output burden (VA)	Accuracy class as per IEC	Formula for min. kV At CT Secondary resistance at 75°C at 300A tap (Volt)	Maximum Exciting Current (mA)	I.S.F./ A.L.F
1	2	3	4	5	6	7	8
1	DIFFERENTIAL PROTECTION	450 -300/0.577	-	PS	40 (RCT+2)	30 at $V_k/4$	-
2	REF PROTECTION	450 -300/1	-	PS	14 (RCT+2)	30 at $V_k/2$	-
3	OVER CURRENT PROTECTION	450 -300/1	25	5P	-	-	10
4	BUSBAR PROTECTION (FOR LOW IMPEDANCE SCHEME)	450 -300/1	-	PS	40 (RCT+4)	30 at $V_k/2$	-
5	METERING	450 -300/1	25	1.0	-	-	<5

NOTE : 4th core for bus bar protection has been kept in view of general design being followed in HVPNL. In case this CT is used on a sub station having high impedance bus bar protection scheme or no bus bar protection scheme then this core shall be short-circuited at site.

TABLE II – A
COREWISE DETAILS OF 245kV LINE/BUS COUPLER CTs
(1200-800-400/1-1-1-1-1 A) NUMBER OF CORES – 5

Core No.	Application	Current Ratio (A)	Output burden (VA)	Accuracy class as per IEC	Formula for min kV At CT Secondary resistance at 75°C at 800A tap (Volt)	Maximum Exciting Current (mA)	ISF
1	2	3	4	5	6	7	8
1.	MAIN-I DISTANCE PROTECTION	1200-800-400/1	-	PS	80(RCT+9)	80 at V_k	-
2.	MAIN-II DISTANCE PROTECTION	1200-800-400/1	-	PS	80(RCT+9)	80 at V_k	-
3.	BUS DIFFERENTIAL MAIN	1200-800-400/1	-	PS	100(RCT+4)	30 at $V_{k/2}$	-
4.	BUS DIFFERENTIAL CHECK	1200-800-400/1	-	PS	100(RCT+4)	30 at $V_{k/2}$	-
5.	METERING	1200-800-400/1	40	0.2S	-	-	ISF<5 for 400/1, ISF<10 for 800/1 ISF<20 for 1200/1.

NOTE:

1. 5 cores of 245kV line CT have been kept in view of general design being followed in HVPNL.
2. In case this CT is used exclusively for bus bar protection purpose on a transformer circuit at sub station having high impedance bus bar protection scheme then core no 1,2 & 5 shall be short circuited at site.
3. In case this CT is used for feeder circuit on a sub station having low impedance bus bar protection scheme then core no. 4 shall be short circuited at site and where there is no bus bar protection scheme core no. 3 & 4 shall be short circuited at site.
4. CT secondary terminals shall be brought out in two separate terminal boxes. Box -1 for Core 1, 2, 3 & 4 and Box 2 for core 5. The second box (Box – 2) shall be provided with proper sealing facility.
5. The provision of auxiliary CT's is not acceptable in 220kV line CT as these are to be used for commercial metering.

TABLE III – A
COREWISE DETAILS OF 245kV POTENTIAL TRANSFORMER (PT)

Sl. No.	Particulars	Requirement	
1.	Rated Primary voltage	220/ $\sqrt{3}$ kV	
2.	Type	Single phase	
3.	No. of Secondaries	2	
4.	Rated voltage factor	1.2 continuous & 1.5 for 30 seconds	
5.	Rated voltage (volts)	Secondary-I 110/ $\sqrt{3}$	Secondary-II 110/ $\sqrt{3}$
6.	Application	Protection & Measurement	Protection
7.	Accuracy	1/3P	3P
8.	Output burden (VA)	150	50
9.	Percentage voltage error & phase displacement (minutes) for respective specified accuracy classes.	As per ISS/IEC	

Note:-

Each winding shall fulfill its respective specified accuracy requirement within its specified output range whilst at the same time the other winding has an output of any value from zero to 100% of the output range specified for the other winding in line with clause 6.2.1 of IS 3156 (Part-2 & Part-3) 1992 or its equivalent IEC.

TABLE I – B

COREWISE DETAILS OF 145kV TRANSFORMER INCOMER CT

(750-500/0.577-1-1-1A)

NUMBER OF CORES – 4

Core No.	Application	Current Ratio (A)	Output burden (VA)	Accuracy Class as per IEC 185	Formula for minimum knee-point voltage At CT Secondary resistance at 75°C at 500A tap (Volt)	Maximum Exciting Current (mA)	I.S.F./ A.L.F.
1	2	3	4	5	6	7	8
1.	DIFFERENTIAL PROTECTION	750-500/0.577	-	PS	40 (RCT+2)	30 at $V_{k/4}$	-
2.	REF PROTECTION	750-500/1	-	PS	90 (RCT+2)	37.5 at $V_{k/2}$	-
3.	OVER CURRENT AND EARTH FAULT PROTECTION	750-500/1	25	5P	-	-	ALF10
4.	METERING	750-500/1	25	1.0	-	-	ISF<5

TABLE II – B

COREWISE DETAILS OF 145kV TRANSFORMER CT

(250-150-100/0.577-1-1-1A)

No. OF CORES = 4

Core No.	Application	Current Ratio (A)	Output burden (VA)	Accuracy class as per IEC 185	Formula for minimum knee-point voltage At CT Secondary resistance at 75°C at 100A tap (Volt)	Maximum Exciting Current (mA)	A.L.F.
1	2	3	4	5	6	7	8
1.	DIFFERENTIAL PROTECTION	250-150-100/0.577	-	PS	40 (RCT+1)	30 at $V_{k/4}$	-
2.	REF PROTECTION	250-150-100/1	-	PS	20 (RCT+1)	30 at $V_{k/2}$	-
3.	OVER CURRENT PROTECTION	250-150-100/1	25	5P	-	-	10
4.	METERING	250-150-100/1	10	0.2S	-	-	ISF<5

TABLE III – B

COREWISE DETAILS OF 145kV LINE CT

(600-300-150/1-1-1A)

No. OF CORES = 3

Core No.	Application	Current Ratio (A)	Output burden (VA)	Accuracy class as per IEC 185	Formula for minimum knee-point voltage At CT Secondary resistance at 75°C at 300A _{tap} (Volt)	Maximum Exciting Current (mA)	A.L.F./ I.S.F.
1	2	3	4	5	6	7	8
1	DISTANCE PROTECTION	600-300-150/1	-	PS	120 (RCT+4.5)	80 at V _{KP}	-
2	OVER-CURRENT & EARTH FAULT PROTECTION	600-300-150/1	25	5P	-	-	ALF 10
3	METERING	600-300-150/1	25	0.2S	-	-	ISF<5 for ratio 150/1, ISF<10 for ratio 300/1, ISF<20 for ratio 600/1

TABLE IV – B

COREWISE DETAILS OF 145kV BUS COUPLER CT

(750-500/1-1A)

No. OF CORES = 2

Core No.	Application	Current Ratio (A)	Output Burden (VA)	Accuracy class as per IEC 185	A.L.F./ I.S.F.
1	2	3	4	5	8
1	OVER-CURRENT & EARTH FAULT PROTECTION	750-500/1	25	5P	ALF 10
2	METERING	750-500/1	25	1.0	ISF<5

TABLE-V B
COREWISE DETAILS OF 145kV POTENTIAL TRANSFORMER (PT).

Sl. No.	Particulars	Requirement		
1.	Rated Primary voltage	132/ $\sqrt{3}$ kV		
2.	Type	Single phase		
3.	No. of Secondaries	3		
4.	Rated voltage factor	1.2 continuous & 1.5 for 30 seconds		
5.	Rated voltage (volts)	Secondary-I 110/ $\sqrt{3}$	Secondary-II 110/ $\sqrt{3}$	Secondary-III 110/ $\sqrt{3}$
6.	Application	Protection & Measurement	Protection	METERING
7.	Accuracy	1/3P	3P	0.2
8.	Output burden (VA)	250	25	20
9.	Percentage voltage error & phase displacement (minutes) for respective specified accuracy classes.	As per ISS/IEC		

Note:- Each winding shall fulfil its respective specified accuracy requirement within its specified output range whilst at the same time the other winding has an output of any value from zero to 100% of the output range specified for the other winding in line with clause 6.2.1 of IS 3156 (Part-2 & Part-3) 1992 or its equivalent IEC.

TABLE I – C
COREWISE DETAILS OF 72.5kV TRANSFORMER INCOMER CT
(1500 - 1000/0.577-1-1-1A)
NUMBER OF CORES - 4

Core No.	Application	Current Ratio (A)	Output burden (VA)	Accuracy class as per IEC 185	Formula for minimum knee-point voltage At CT Secondary resistance at 75°C at 1000A tap (Volt)	Maximum Exciting Current (mA)	A.L.F./ I.S.F.
1	2	3	4	5	6	7	8
1	DIFFERENTIAL PROTECTION	1500 1000/0.577	-	PS	40 (RCT+2)	30 at $V_{K/4}$	-
2	REF PROTECTION	1500 – 1000/1	-	PS	14 (RCT+2)	30 at $V_{K/2}$	
3	OC& E/FAULT PROTECTION	1500 – 1000/1	15	5P	-	-	ALF 10
4	METERING	1500 – 1000/1	15	1.0	-	-	ISF <5

TABLE II – C
COREWISE DETAILS OF 72.5kV BUS COUPLER CT FOR 220KV S/STN.
(1500-1000/1-1)
No. OF CORES = 2

Core N	Application	Current Ratio (A)	Output burden (VA)	Accuracy class as per IEC	A.L.F./ I.S.F.
1	2	3	4	5	8
1	OC& E /FAULT PROTECTION	1500-1000/1	15	5P	ALF 10
2	METERING	1500-1000/1	20	1.0	ISF<5

TABLE III – B
COREWISE DETAILS OF 72.5kV POTENTIAL TRANSFORMER (PT)

Sl. No.	Particulars	Requirement	
1.	Rated Primary voltage	66/ $\sqrt{3}$ kV	
2.	Type	Single phase	
3.	No. of Secondaries	2	
4.	Rated voltage factor	1.2 continuous & 1.5 for 30 seconds	
5.	Rated voltage (volts)	Secondary-I 110/ $\sqrt{3}$	Secondary-II 110/ $\sqrt{3}$
6.	Application	Protection & Measurement	Protection
7.	Accuracy	1/3P	3P
8.	Output burden (VA)	250	25
9.	Percentage voltage error & phase displacement (minutes) for respective specified accuracy classes.	As per ISS/IEC	

Note:- Each winding shall fulfill its respective specified accuracy requirement within its specified output range whilst at the same time the other winding has an output of any value form zero to 100% of the output range specified for the other winding in line with clause 6.2.1 of IS 3156 (Part-2 & Part-3) 1992 or its equivalent IEC.

ANNEXTURE A

TECHNICAL SPECIFICATION FOR SPECIAL EQUIPMENTS

This part of the document covers detailed technical requirement for the diagnostic tools complete with associated components and accessories including required software for storage of data and interpretation of results etc.

1.0 DEW POINT METER

The meter shall be capable of measuring the dew point of SF6 Gas of the Circuit Breaker/ GIS equipment. It should be portable and adequately protected for outdoor use. The meter shall be provided with dew point hygrometer with digital indication to display the dew point temperature in degree C., degree F or PPM. It should be capable of measuring the corresponding pressure at which dew point is being measured.

The measurement and use of the instrument must be simple, direct without the use of any other material/ chemical like dry ice/ acetone etc. It should be suitable for operation on 220 Volts AC mains supply.

TECHNICAL SPECIFICATION:

1. Measuring Range: Upto-100 ° C dew point.
2. Accuracy : $\pm 2^\circ \text{C}$.
3. Display: 4 digit LCD, 0.5 inch high.

2.0 DIGITAL MICRO-OHM METER FOR CONTACT RESISTANCE MEASUREMENT

2.1 General requirements

- 2.1.1. The equipment shall contain all standard accessories including test leads of 20 meters with suitable clamps / connectors and carrying case.
- 2.1.2. It should offer repeatability of test results in charged switchyard conditions.
- 2.1.3. The test kit shall be compatible for EMI/EMC environment as per IEC-1000
- 2.1.4. As per requirement of ISO-9001, Calibration certificate for each testing instrument covering entire range shall be supplied with the test kit at the time of supply.
- 2.1.5. The testing equipment is generally meant for carrying out testing at the site and movement from one place to another is unavoidable. Therefore equipment shall be robust in design so that it gives desired performance even in adverse site conditions.
- 2.1.6. Environmental condition such as temperature, humidity vibration bump etc. shall be as per IS: 9000 and IS: 9001 or equivalent standards. Required certificates conforming to above standards shall be furnished along-with the offer.
- 2.1.7. Necessary transport packing arrangement shall be supplied along with the instrument(s).
- 2.1.8. The equipment shall generally comply with the requirement of relevant Indian standards or equivalent to International standards such as IEC, BS, ASTM,ISO etc.
- 2.1.9. Supplier should have adequate "after sale services" facility in India.

2.2 Technical Specification

The test kit shall be portable, light in weight, robust and tropicalized to suit outdoor applications such as circuit breaker isolator contact resistance measurement etc. It shall be battery operated, rechargeable and should include all accessories like probes, test leads, clamps for use of conductors size upto 35 mm dia. The test instrument shall provide contact resistance in digital display.

Technical requirements

Measured resistance Range: 1 micro ohm to 2000 micro ohm.

Resolution: 1 micro ohm,

Accuracy: Value: $\pm 2.5\%$.

Test Current : 100A DC,

Type: Portable direct reading (digital type) of multi resistance ranges. It shall be battery operated rechargeable) and also mains (240 Volt Single Phase AC)

3.0 CIRCUIT BREAKER OPERATIONAL ANALYSER

General : Main Equipment

- i. The Computer Aided CB Analyzer system comprising of CB operation unit, programme unit, travel analyzer unit & analysis software should be capable to perform close, open, close-open, open-close, open-close, open operation on CB under test, with a facility to introduce time delays between composite operation.
- ii. The CB Analyzer should be capable to measure, record and analyze the CB operation timing.
- iii. The CB Analyzer should be able to measure and record current rise and fall of tripping

- coils as well as of closing coils of all three poles of CB simultaneously.
- iv. The CB Analyzer should be capable to measure and record travel and speed of movement of operating mechanism of CB.
 - v. The CB Analyzer should be capable to measure and record dynamic contact resistance of main and arcing contacts of CB with injection of minimum 100 Amp. DC current.
 - vi. The CB Analyzer should be capable to measure pole discrepancy timing.
 - vii. The CB Analyzer should be capable of measuring contact closing & opening timing up to four (04) main and four (04) no. PIR contact.
 - viii. The CB Analyzer should be capable to calculate and print all contact closing & opening tuning in tabular form also.
 - ix. Suitable mounting kits for transducers and sensors, alongwith sensor cable of suitable length should be supplied with CB analyzer system.
 - x. Test leads with suitable clamp and connectors and having length suitable for leads with suitable clamp and connectors and having length suitable for connection to EHV CBs should be supplied with CB Analyzer system for
 - xi. Necessary custom built travel transformer cum fixtures suitable for mounting on BHEL/ABB/CGL/Siemens/ALSTOM (66 KV and above) makes of CBs, to monitor travel related parameters like contact gap. Contact insertion, over travel etc. should be supplied with CB Analyzer.
- System Operation hardware/software, peripherals and analysis software.**
- i. The test report for recording motion should provide test results both in form of curve and tables. The tables should consist of calculated CB parameters such as closing/opening speed etc.
 - ii. The entry of various data/parameters (pertaining to CB) be possible using built in display of menu.
 - iii. The battery backup and real time clock should be provided for automatic date and time functions.
 - iv.
 - a) The computer aided analysis software should have sampling frequency upto 40 KHz or more.
 - b) The analyzer should be capable to record transient phenomenon for a duration at least 500 ms.
 - v. The binary channel accuracy and analogue channel accuracy should be suitable meet all desired functions(stated above)
 - vi. The CB analyzer should be provided with facility of down loading data to a IBM compatible PC. Also the CB analyzer should be provided with facility of down loading data to Laptop to be provided with portable partial discharge monitor for GIS.
 - vii. The printer provided with CB analyzer should be preferably a plain paper printer.
 - viii. The computer aided CB analysis software should be supported with suitable report generation.
 - ix. It should be possible to change scale factor of time axis to enable enlarged view of part of diagram.
 - x. It should be possible to change amplitude scale to make best use of available space.
 - xi. It should be possible to study on speed curve, the damping and speed variations at CB opening and closing time.
 - xii. The CB analyzer should be supplied with portable memory bank to store test result taken by test kit to enable further down loading to centrally located PC.
 - xiii. Window based PC down loading software should be provided with CB analyzer to facilities downloading test result from memory bank to PC where it can be analyzed and stored in proper directory/file.
 - xiv. It should be possible to compare present results with previous one. The feature of Zooming the graph and moving the cursors on graph, thereby indicating instantaneous values of test parameters should also be provided.
 - xv. The latest version of CB analyzer system (hardware's and software's) to be supplied and time to time updating of software should be offered.

- xvi. As and when required, technical support for analysis of critical test result to be offered, on regular basis.
- Other Essential Requirements.**
- i. The CB analyzer should operate on power supply of 220 volts ($\pm 10\%$) at 50 Hz ($\pm 5\%$) frequency.
 - ii. The CB analyzer should be capable of working in high electro-magnetic and electrostatic conditions.
 - iii. The CB analyzer should be capable of functioning accurately in environmental condition of temperature 0° to 50° C and humidity (RH) up to 95 % (non-condensing).
 - iv. The CB analyzer should be portable so as to facilitate movement from one site to other and supplied with suitable transportation case.
 - v. The supplier should have adequate after sale service facility.
 - vi. As per ISO: 9001 requirement, calibration certificates for each instrument should be supplied.
 - vii. Installation :
 - a) Indoor/outdoor
 - b) The equipment should be portable easy to handle robust and sturdy, for field applications.

4.0 SF6 GAS LEAK DETECTOR

The SF6 gas leak detector shall comprise of circuit breaker operation unit/GIS Module, programme unit, travel analyzer, analyzer software and transducers and other accessories.

4.1 The detector shall be free from induced voltage effects.

4.2 The sensing probe shall be such that it can reach all the points on the breaker/GIS module where leakage is to be sensed.

5.0 PORTABLE PARTIAL DISCHARGE MONITOR

5.1 GENERAL

The equipment shall be used for detecting different types of defects in Gas Insulated Stations (GIS) such as Particles, Loose shields and Partial Discharges as well as for detection of Partial discharges in other types of equipment such as Cable Joints, CTs and PTs.

5.1.1 It shall be capable for measuring PD in charged GIS environment as EHV which shall have bandwidth in order of 10 KHz – 500 KHz with possibility to select a wide range of intermediate bandwidths for best measurement results. The principle of operation shall be on acoustic technique and the method of measurement shall be non-intrusive. The instrument is able to detect partial discharges in cable joints, terminations, CTs and PTs etc., with the hot sticks.

5.1.2 Detection and measurement of PD and bouncing particles shall be displayed on built in large LCD display and the measurement shall be stored in the instrument and further downloadable to a PC for further analysis to locate actual source of PD such as free conducting particles, floating components, voids in spacers, particle on spacer surfaces etc.

5.2 TECHNICAL SPECIFICATION:

5.2.1. Measurement shall be possible in noisy environment.

5.2.2. Stable reading shall be possible in presence of vibrations within complex GIS assemblies, which can produce signals similar to PD.

5.2.3. Equipment should have necessary synchronizing circuits to obtain PD correlation with power cycle and power frequency.

5.2.4. The equipment shall be battery operated with built-in-battery charger. It shall also be suitable for 230V AC/50 Hz input.

5.2.5. Measurement shall be possible in the charged switchyard in the presence of EMI/EMC. Supplier should have supplied similar detector for GIS application to other utilities. Performance certificate and the list of users shall be supplied along with the offer.

5.2.6. Instrument shall be supplied with standard accessories i.e., re-locatable sensors with mounting arrangements, connecting cables (duly screened) to sensors, Lap-top (i5/i7 or higher version fully compatible with PD measurement device & CB Analyser with required software's), diagnostic software, carrying case, rechargeable battery pack with charger suitable for 230V AC, 50Hz supply connecting cables (duly screened) to view in storage.

- 5.2.7. The function of software shall be covering the following:
- Data recording, storage and retrieval in computer
 - Data base analysis
 - Template analysis for easy location of fault inside the GIS
 - Evaluation of PD measurement i.e, Amplitude, Phase Synchronization etc.
 - Evaluation of bouncing/loose particles with flight time and estimation on size of particle.
 - Report generation
- 5.2.8. To prove the suitability in charged switchyard condition, practical demonstration shall be conducted before acceptance.
- 5.2.9. Supplier shall have “Adequate after sales service” facility in India.
- 5.2.10. Necessary training may be accorded to personnel to make use of the kit for locating PD sources inside the GIS
- 5.2.11. Instrument shall be robust and conform to relevant standard.

6.0 SPECIFICATION FOR DIGITAL EARTH RESISTANCE METER

6.1 General:

Digital Earth Resistance Meter shall be used to measure earth resistance of substations, power transmission towers, building rods, primary cabins etc. & soil-resistivity at 220kV Substations.

6.2 General Requirements:

- 6.2.1. The calibration certificate should be supplied with test kit (for entire range).
- 6.2.2. If supplier is not the manufacturer, maintenance facility should be available with the supplier.
- 6.2.3. The earth testing kit should be supplied complete in all respect i.e. with suitable spikes and test leads etc.
- 6.2.4. The meter should have synchronous internal Generator to inject AC current.
- 6.2.5. The meter should have suitable circuit to regulate the current automatically.
- 6.2.6. The meter should comply with IP54 class for Environmental protection.
- 6.2.7. The Instrument should meet safety class requirements as per IEC 61010-1/1990 or equivalent.
- 6.2.8. The Instrument should meet IEC 61326-1 or equivalent for EMC.
- 6.2.9. The Instrument should have CE marking.
- 6.2.10. The meter should weigh not more than 3 kg.

6.3 Functional Requirements:

- 6.3.1. Suitable to measure resistance of earth electrode and resistivity of soil.
- 6.3.2. Comply with testing requirements set by international standards.
- 6.3.3. Measurement should not be influenced by electrostatic/electromagnetic interference present in EHV switchyards.
- 6.3.4. Indication for condition of battery should be provided e.g. “Low-Battery” OR “Replace-Battery” OR “Charge-Battery” etc.

6.4 Range and Accuracy:

- | | | |
|---------|-----------------------------|--|
| 6.4.1. | Earth Resistance Range | 0 Ω to 1.99 K Ω (in multiple ranges of 0 to 0.99 Ω , 1 to 9.99 Ω , 10 to 99.9 Ω & 100 Ω to 1.99 K Ω) |
| 6.4.2. | Accuracy | $\pm 2.0\% + 3$ digits or better |
| 6.4.3. | Resolution | 0.01 |
| 6.4.4. | Maximum output voltage | ≤ 50 Volts |
| 6.4.5. | Test current | ≤ 30 mA |
| 6.4.6. | Environmental conditions: | |
| 6.4.6.1 | Operating Temp | Up to 50°C |
| 6.4.6.2 | Operating R.H. | Up to 90% (at 40°C) non condensing |
| 6.4.7. | Power supply: | |
| 6.4.7.1 | Rechargeable battery/cells. | |
| 6.4.7.2 | Charger | Internal/external |
| 6.4.7.3 | Charger | Suitable for 230 Volts Single phase 50 Hz AC supply. |

7.0 5 kV AUTOMATED INSULATION RESISTANCE TESTER

7.1 Description:

The Tera Ohm shall be of ultra high range insulation resistance testing instrument. With

an output voltage to 5000 Volts DC and suitable for measurement up to 5T (5,000,000 Meg Ohm).

The instrument should be such that its test voltage can be selected in increments of 50 Volts, the duration of the test can be set by the operator, at the end to the test period, the sample is automatically discharged and the insulation resistance is indicated on the display.

Polarization Index tests can also be automatically conducted. At the end of the ten minute period, PI is automatically calculated and up to 1000 results can be stored in the instrument. These results can easily be recalled or can be transferred to a PC/Laptop using the optional windows software Tera Link+.

The instrument can also be used to measure capacitance up to 50 μ F, voltage up to 600 VAC or VDC, and frequency.

7.2

SPECIFICATIONS:

a)	Insulation test	0.01M to 5T , $\pm 5\%$ accuracy
b)	DC Test Voltage	250 to 5000V in 50V steps. Actual test voltage display, $\pm 3\%$ accuracy
c)	Test Current	> 1 mA, 5W max.
d)	Voltage Measurement	0 to 600V AC or DC, $\pm 3\%$ accuracy
e)	Frequency Measurement	45 65 Hz, ± 0.2 Hz
f)	Withstanding Voltage	0 to 5000V, 0 to 1.4mA, $\pm 3\%$ accuracy
g)	Capacitance	0 to 50 μ F, $\pm 5\%$ accuracy
h)	Polarization Index (PI)	0 to 99.9, $\pm 5\%$ accuracy
i)	Dielectric Discharge (DD)	0 to 99.9, $\pm 5\%$ accuracy
j)	Protection	Double insulation, CAT III 600V, Pollution degree 2
k)	Power	6 "C" size re-chargeable batteries & 230V AC