ANNEXURE-1A TO PY55294

STANDARD SPECIFICATION FOR 33kV GAS INSULATED SWITCHGEAR

PROJECT	**75MW VISAKH REFINERY MODERNIZATION PROJECT (VRMP)**
CUSTOMER	**M/S HINDUSTAN PETROLEUM CORPORATION LIMITED,VIZAG,A.P**
CONSULTANT	**ENGINEERS INDIA LIMITED**

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1.0 SCOPE

1.1 This specification covers the design, engineering, manufacture, testing, packing and supply of 33kV Gas Insulated Switchgear (GIS).

1.2 The switchgear shall be complete in all respects and any device not included in the specification but essential for proper operation of equipment shall be deemed to be within the scope of the specification whether specifically mentioned in Specification or not.

2.0 CODES & STANDARDS

2.1 The equipment shall comply with the requirements of latest revision of the following standards issued by BIS and International Standards, unless otherwise specified. In case Indian standards are not available for any equipment, standards issued by IEC/BS/VDE/IEEE/NEMA or equivalent agency shall be applicable:

IS:1248	Direct acting indicating analogue electrical measuring instruments and their accessories.
IS:2071	High Voltage Test Technique
IS:2705	Current transformers
IS:3156	Voltage transformers
IS:5082	Material data for aluminium bus bars
IS:5578	Guide for marking of insulated conductors
IS:9920	Switches and switch isolators for voltages above 1000 V
IS:9921	AC disconnectors (isolators) and earthing switches for voltage above1000V
IS:11353	Guide for uniform system of marking and identification of conductors & apparatus terminals
IS:12729	Common high voltage switchgear and control gear standard
IS:13118	General requirements for circuit breakers for voltages above 1000 V
IS:13703	Low voltage fuses for voltages not exceeding 1000V AC or 1500V DC.
IEC:60059	IEC Standard Current Rating
IEC:60060	High voltage test techniques
IEC:60099-4	Metal - Oxide surge arresters without gaps for a.c. systems.
IEC 60114	Recommendation for heat treated al alloy bus bar material of al. Magnesium —silicon type.
IEC 60137	Bushings for alternating voltages above 1000 V
IEC 60255	Electrical Relays
IEC 60270	High voltage test techniques - Partial discharge measurement
IEC 60376	Specification of technical grade sulphur hexafluoride (SF6) for use in electrical equipment
IEC 60480	Guidelines for the checking and treatment of sulphur hexafluoride (SF6) taken from electrical equipment and specification for its re-use
IEC 60529	Degrees of protection provided by enclosures (IP Code).
IEC 60694	Common specification for high voltage switchgear and control gear Standards
IEC 61243-1	Live working - Voltage detectors — capacitive type to be used for voltages exceeding 1 kV a.c. Instrument transformers/General requirements
IEC 61869-1	Instrument transformers/General requirements
IEC 61869-2	Additional requirements for current transformers
IEC 61869-3	Additional requirements for inductive voltage transformers
IEC 62271- 4	Handling procedures for sulphur hexafluoride (SF6) and its mixtures
IEC 62271-100	High voltage alternating current circuit breakers.
IEC 62271-102	Alternating current disconnectors (isolators) and earthing switches
IEC 62271-110	High voltage switchgear and controlgear - Inductive load switching
IEC 62271-200	AC metal-enclosed switchgear & control gear for rated voltages Above 1 kV and up to and including 52 kV.

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2.2 In case of imported equipment, standards of the country of origin shall be applicable, if these standards are equivalent or stringent than the applicable Indian standards.

2.3 The equipment shall also conform to the provisions of CEA regulations and other statutory regulations currently in force in the country.

2.4 In case of any contradiction between various referred standard/ specification/ data sheet and statutory regulation, most stringent requirements shall prevail. However, Owner's decision in this regard will be final and binding.

3.0 GENERAL REQUIREMENTS

3.1 The offered equipment shall be brand new with state of art technology and proven field track record. No prototype equipment shall be offered.

3.2 Vendor shall ensure availability of spare parts and maintenance support services for the offered equipment for at least 15 years from the date of supply.

3.3 Vendor shall give a notice of at least one year to the end user of equipment and EIL before phasing out the product/spares to enable the end user for placement of order for spares and services.

4.0 SITE CONDITIONS

4.1 The Gas Insulated Switchgear shall be suitable for installation and satisfactory operation in pressurized sub-station or in a substation with restricted natural air ventilation in a tropical, humid and corrosive atmosphere.

4.2 The Gas Insulated Switchgear shall be designed to operate under site conditions as specified in the main specification PY55294.

4.3 All equipments described in this specification are intended for continuous duty operation, as per nameplate rating under the specified ambient conditions, unless indicated otherwise.

5.0 DESIGN AND FABRICATION REQUIREMENTS

5.1 **Enclosure and Protection**

5.1.1 The switchgear shall be an indoor gas-insulated, metal clad cubicle design with single bus bar system, assembled to form freestanding, self supporting dead front structure. Vertical units shall be assembled to form a continuous line-up of uniform height. It shall be suitable for local and remote control through Local/ Remote selector switch. It shall be designed to ensure optimum continuity and reliability of supply as well as safety during operation.

5.1.2 The degree of protection shall be at least IP65 for gas compartments and IP4X for low voltage compartments as specified in IEC 60529.

5.1.3 The switchgear line-up when installed and operating under the ambient conditions shall perform satisfactorily and safely under all normal and fault conditions. Any fault shall be positively confined to the originating compartment and shall not spread to other parts of the switchgear.

5.1.4 The switchgear shall be of modular design and capable of extension in future by the addition of extra feeders without necessarily dismantling any major parts of the equipment.

5.1.5 The enclosure for the SF6 gas and associated circuit elements shall be made from non- magnetic material. The type of material and thickness shall also be such so as to keep heating due to induced circulating currents to a minimum. Enclosures of the same phase shall be electrically interconnected, and shall be earthed at appropriate places.

5.1.6 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.

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

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5.1.8 Any paints or other coatings that may be used shall be such that they will not deteriorate when exposed to the SF6 gas and other vapours, arc products, etc. that may be present in the enclosures. They shall also not contain any substances which could contaminate the enclosed SF6 gas or affect its insulating properties over a period of time.

5.1.9 The guaranteed leakage rate of each individual gas compartment must be less than 0.5 % p.a. over the lifetime of the Switchgear. Initial Filling of the equipment must guarantee gas service periods of not less than 10 years.

5.1.10 Breaker bay shall consist of at least the following arc and SF6 gas-tight high voltage compartments:

- Circuit breaker compartment.
- Disconnectors/earthing switches.
- Bus-bar compartment.

However, Combined bus-bar and disconnector / earthing switches compartment can be provided.

5.1.11 All SF6 gas tight compartments must have their own independent gas supervision and alarm systems with contact of density gauges/pressure switches for alarm and indication.

5.1.12 Cable installation work on functional units (replacements or new installations) and modification of spare panels shall be safely possible without adjacent units having to be de-energized.

5.1.13 The Loss of Service Continuity category (LSC) of the switchgear shall be LSC2B and partition class PM according to IEC 62271-200.

5.1.14 Expansion joints or flexible connections shall be provided in the metal enclosure /conductors to absorb the actual or relative thermal expansion and contraction of the SF6 equipments resulting from variations of the temperature of the switchgear equipment. Suitable mounts and compensators shall be provided where necessary without detriment to the current carrying capacity or gas volume.

5.1.15 Bus bars and items of switchgear shall be supported in the enclosures by insulators of materials compatible with SF6 gas and the products of gas decomposition. Gas barrier insulators shall comply with the specified conditions for sealing of enclosures.

5.1.16 The low voltage compartment shall contain the switch operating mechanisms and all secondary equipment including protection and control devices and the plug connectors for the auxiliary power connection and serial communication.

5.1.17 Automatic pressure relief shall be incorporated in the basic design of the enclosures as a precaution against explosion in the event of an intemal arc fault. Pressure relief shall be provided for all high voltage compartments including SF6 Gas and air insulated enclosures. Relief into cable cellar/trench shall not be provided.

5.1.18 The switchgear gas enclosures shall be sectionalised with gas tight barriers between sections. Gas section barriers including seals to the conductor and enclosure wall shall be gas-tight and shall be capable of withstanding the maximum pressure differential that could occur across the barrier, i.e. with vacuum drawn on the one side of the barrier and on the other side, at least twice the rated gas pressure that can exist under normal operating & maintenance conditions or the maximum gas over pressure equal to the operating pressure of the relief devices that could be attained with internal arc fault.

5.1.19 All gas seals shall be designed to ensure that leakage rates are kept to an absolute minimum under all normal pressure, temperature, electrical load and fault conditions.

5.1.20 The rated pressure of the SF6 insulating gas in the metal clad equipment shall be as low as is compatible with the requirements for electrical insulation and space limitations to reduce the effects of leaks and to ensure that there is no chance of the gas liquefying at the lowest ambient temperature. The initial gas pressure or density at the time of charging the equipment shall provide a sufficient margin above the minimum allowable operating pressure for the plant to be safely operated for a reasonably long period before recharging is necessary.

5.1.21 The SF6 switchgear shall be designed for use with SF6 gas complying with the recommendations of IEC 60376. The SF6 gas supplied shall comply with the requirements of IEC 60376 as a minimum.

5.1.22 The panels must safely withstand at least the rated lightning impulse voltage as per standards even when the gas pressure falls to atmospheric level.

5.1.23 All operating mechanisms shall be of motorized type. Manual emergency operation and mechanical position indicators shall also be provided.

5.2 **Accessibility:**

5.2.1 All relays, metering, and control components shall be mounted on the panel front only.

5.2.2 Checking and removal of components shall be possible without disturbing adjacent equipment. All equipment shall be easily accessible. It shall be possible to set all measuring relays and instruments in situ without de-energising the switchboard. Al1 mounted equipment shall have identification tags of self-sticking tapes at the rear also. In addition, identifications numbers shall be painted on the panel to give a permanent identification mark. Mounting of relays for a particular breaker feeder panel shall be limited to that particular feeder only.

5.2.3 Al1 terminals shall be shrouded with plastic covers to prevent accidental contact.

5.3 **Bus bar:**

5.3.1 Bus bars shall be of high conductivity electrolytic copper supported on insulators made of non-hygroscopic, non-inflammable material with tracking index equal to or more than that defined in standards. Single bus schemes shall be provided as specified in the data sheets.

5.3.2 The switchgear shall comprise of 3-phase bus bars housed in either single phase or 3- phase enclosures. The main bus bars shall have uniform cross-section throughout their length and shall be sized to carry continuously the rated current specified in the data sheet.

5.3.3 The current rating as defined for switchgear and components in data sheet are for design ambient temperature at site conditions and for inside the enclosure at fully loaded condition. The vendor shall suitably derate the nominal rating to suit the above condition. Every current-carrying part of the switchgear including current transformers, disconnecting switches, bus bars, connections and joints shall be capable of carrying its specified rated normal current continuously and in no part shall the temperature rise exceed the values specified in relevant standards. Any derating to meet site ambient conditions shall be taken into account.

5.3.4 The bus bars and the supports shall be adequately sized and braced to withstand the specified short-circuit current without permanent deformation. Dynamic stresses shall be calculated on the basis of the specified peak short-circuit current. All bus supports shall be of non-carbonising material, resistant to acids and alkalies.

5.3.5 Suitable clearance between phases and between live parts and enclosure shall be provided to keep it safe for the operator to approach and even to touch the enclosure in the worst case of gas leak, i.e., when the pressure inside the enclosure becomes equal to the air pressure outside the Switchgear.

5.3.6 Busbar earthing facilities for each section of the bus bars, completely interlocked with associated disconnectors & CBs of that section of bus bars including bus coupler/sectionaliser shall be provided.

5.4 **Cable Termination:**

5.4.1 A11 HV Power cables and control cables will be connected from below through cut-outs in the floor or through cable trench. To maintain the totally insulated design concept of the Switchgear, only fully insulated plug-in type terminations with direct solid dielectric-to-gas insulation shall be used power cables. Plug in Terminations (including plugs, sockets) and all accessories shall be provided for all feeders including for spare feeders by vendor.

5.4.2 Suitable arrangements of test plug / socket shall be provided in cable compartment which will permit full dielectric testing for outgoing cable of all cable feeders including primary current injection test for current transformers.

5.4.3 Provision for cable termination of XLPE cables i.e cable termination kits/plug and sockets shall be considered for outgoing cable feeders and for incoming cables for requisite cable size mentioned in

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Annexure-06. When single-core cables are used, non magnetic gland plates shall be provided. Sufficient space must be provided in the Switchgear panels to terminate and connect required cables.

5.5 **Auxiliary Wiring and Terminals:**

5.5.1 Inside the cubicles, the wiring for control, signalling, protection and instrument circuits shall be FRLS type, copper conductor wire. The insulation grade shall be 660 V. The wiring shall preferably be enclosed in plastic channels or neatly bunched together. Wiring between HV breakers or cable compartments to Low voltage compartments shall be routed through flexible conduits.

5.5.2 A minimum of 20% spare terminals shall be provided. Sufficient terminals shall be provided on each terminal block to ensure that not more than one outgoing wire is connected per terminal. Terminal strips shall preferably be separated from power circuits by metal barriers or enclosures. All spare contacts of auxiliary relays, timers, etc shall be wired up to the terminals.

5.5.3 Copper conductor of cross section 1.5 mm^2 may normally be used provided the control fuse rating is 10A or less. For 16A control fuse circuit 2.5 mm^2 copper conductors shall be used. CT Circuit wiring shall be done with 2.5 mm^2 copper conductors. Shorting links / suitable shorting arrangement for shorting CT secondary shall be provided.

5.5.4 Each wire shall be identified at both ends by correctly sized ferrules. The CT terminal blocks shall have shorting, isolation and injection test facilities whereas VT terminals shall have isolation and injection test facilities.

5.5.5 All inter-panel control wiring within each shipping section shall be by switchgear vendor. The inter-panel wiring shall be taken through sleeves or suitable grommets. For inter-panel wiring between the shipping sections, wires in rolls of the required length, connected at one point, shall be supplied with the panel for connection at site.

5.6 **Earthing of metallic parts:**

5.6.1 The switchgear shall have earthing pads for connection with earth grid. Suitable earthing arrangement shall be provided for incoming and outgoing side earthing of panels.

5.6.2 All metal parts of the Switchgear and all integral earthing features shall be connected directly to a copper earth bar, which shall be provided running along the full length of the switchgear.

5.6.3 All doors and movable parts shall be connected to the earth bus with flexible copper connections. Provision shall be made to connect the earthing bus bar to the plant earthing grid at two ends. All noncurrent-carrying metallic parts of the equipment and components shall be earthed. The earth bus shall be brought to the cable compartment, and earthing bolts shall be provided to earth cable armour. The mating surfaces of all bolted parts shall be zinc passivated to ensure continuity between them.

5.6.4 The enclosure of the GIS may be earthed at several points so that there shall be earthed cage around all the live parts. A minimum of two nos. of earthing connections shall be provided for each of circuit breaker, cable terminals, surge arrestors, earth switches and at each end of the bus bars. The earthing continuity between each enclosure shall be effectively interconnected with Cu bonds of suitable size to bridge the flanges.

5.6.5 All flexible bonding leads shall be tinned copper. The minimum earth bus bar size of 300 mm^2 copper for earthing the GIS enclosures and supporting structures shall be provided.

5.7 **Space Heaters:**

5.7.1 The panels shall be provided with space heaters to prevent moisture condensation, and maintain cubicle temperature 5°C above the ambient. The space heaters shall be controlled through a double pole MCB and thermostat Space heaters shall be supplied from 240V AC auxiliary bus for space heater.

5.8 **Panel supporting frame:**

5.8.1 The panels shall be suitable for installation on base frame supplied by vendor along with foundation bolts. Amply-dimensioned oblong holes shall be provided at the bottom of all the panels for their installation on the base frame.

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5.8.2 The panels with base frame shall be suitable for installation on panel supporting frame. The panels shall be suitable for tack welding directly to the frame.

5.8.3 Details of Suitable embedment in the foundation floor as required for supporting the switchgear assembly, necessary supporting framework, leveling screws, etc. to fasten the switchgear base frames to the embedment in foundation floor shall be provided by vendor. Vendor shall provide drawing showing all details of the embedded parts and installation details required on the floor.

5.9 **Nameplates:**

5.9.1 Engraved nameplates shall preferably be of 3- ply (Black-White-Black) lamicoid sheets or anodised aluminium. However back engraved perspex sheet nameplates shall also be acceptable. Nameplates shall be fastened by screws and not by adhesives. A weather-proof and corrosion-proof name plate shall be provided and shall conform to applicable standards.

5.9.2 A nameplate with the switchgear designation shall be fixed at the top of the central panel. A separate nameplate giving details for each feeder compartment of all panels shall be provided. Danger plate (Red) shall be provided at the front and rear for each panel.

5.9.3 Blank nameplates shall be provided for all spare and vacant modules.

5.9.4 Each of the equipment devices including CB, Disconnector switch, Earthing switch, CT, VT, and busbars etc. mounted inside the switchgear shall be provided with proper nameplate and rating plate. All information as per the latest edition of relevant IEC standards shall be included. Special warning plates shall be provided on removable covers or doors giving access to cable terminals and bus bars.

5.9.5 Special warning labels shall be provided inside the switchgear also, wherever considered necessary. Identification tags shall be provided inside the panels matching with those shown on the circuit diagram.

5.10 **Painting:**

5.10.1 The switchgear shall be treated and protected to withstand continuous operation under site conditions without sustaining corrosion or attacks from fungus or rodents. The protective finish shall prevent deterioration due to corrosion, humidity, temperature, ageing and weather etc. under site conditions.

5.10.2 All metal surfaces shall be thoroughly cleaned and degreased to remove mill scale, rust, grease and dirt. All exterior surfaces shall be cleaned and epoxy painted before leaving the factory with one coat of approved primer and two coats of approved equipment finish paint. Fabricated structures shall be pickled and then rinsed to remove any trace of acid. The under surface shall be prepared by applying a coat of phosphate paint and a coat of yellow zinc chromate primer. The underside of all surfaces bearing upon the concrete foundation shall be given two coats of approved primer. The under surface shall be made free from all imperfections before undertaking the finishing coat. Panel finish shall be free from imperfections like pinholes, orange peels, runoff paint etc.

5.10.3 External Colour shade of final paint shall be as RAL7032 unless specified otherwise.

5.10.4 All unpainted steel parts shall be Zinc passivated or Cadmium plated or suitably treated to prevent rust formation. If these parts are moving elements, then they shall be greased.

5.10.5 Gas monitoring and service piping including all fittings and accessories shall be made of copper, brass or stainless steel.

5.11 **Interlock system:**

5.11.1 The interlock System must positively prevent an Operator from reaching or creating unintentionally a dangerous or potentially dangerous condition.

5.11.2 Specifically the following conditions must be impossible to reach:

i) Electrically and manually operating the breaker with the disconnector / earthing switch not fully engaged in any of its three positions.

ii) Electrically and manually closing or opening of the disconnector / earthing switch while the breaker is closed.

iii) Electrical closing of the disconnector switch, while the earthing switch at the remote end is closed.

iv) Electrical closing of the earthing switch while the remote end disconnector/circuit breaker is in closed position.

5.11.3 When the manual emergency cranks are used, it shall be impossible to control the devices electrically.

5.11.4 Electrical interlocks shall be provided between Bus-bar Earthing Switches and all Bus-bar disconnectors of each Bus-bar Section in such a way that Bus-bar Earthing Switches can not be closed when the Bus-bar disconnectors of any circuit in the section is closed. Bus VT Miniature Circuit Breaker (MCB) ON auxiliary contacts and under voltage relay contacts shall be monitored in the interlocking scheme to confirm the dead bus condition.

5.11.5 Bus-bar disconnectors of any circuit shall not close electrically or manually while a Bus-bar Earthing Switch is closed.

5.12 **Interface requirements:**

5.12.1 As a minimum, the following annunciation signals from incoming, bus-coupler, outgoing feeders and line/Bus VT shall be available for Owner's use. Potential free contacts shall be provided as required:

i) Breaker ON
ii) Breaker OFF
iii) Tripped on fault
iv) Under-voltage trip
v) Trip circuit unhealthy
vi) VT Secondary MCB off
vii) DC Control Supply failure

Other contacts for annunciation shall be provided as required.

5.12.2 All potential free contacts shall be duly wired to the terminal blocks in the respective panel for onward wiring by Purchaser.

5.13 **Internal Fault:**

5.13.1 The switchgear shall be qualified as classification IAC according to IEC 62271-200 with regard to its mechanical strength in the event of an internal arc. The test performance shall be in conformity with accessibility type AFLR.

5.13.2 The test shall be executed for all separate compartments within the functional unit containing HV equipment, i.e., bus-bar compartment, circuit breaker / contactor compartment and cable compartment.

5.14 **Gas Monitoring system:**

5.14.1 Each gas filled compartment, shall be fitted with a temperature compensated pressure switch. It shall be directly secured on the enclosure, and shall have two threshold levels to continuously monitor the gas density. With the first level operating, the user shall be required to refill the compartment with SF6 gas as soon as possible while keeping GIS in service. On operation of the second level, the user shall be required to de-energise the compartment.

5.14.2 Each gas filled compartment shall also be fitted with:

i) one SF6 gas filling and draining valve with automatic shut off and quick coupling device.
ii) one safety diaphragm designed to prevent any bursting of enclosure, should an internal fault or an abnormal pressure increase occur.
iii) one absorbent filter to retain moisture.

5.14.3 GIS shall have suitable provision for gas pressure limitation and control.

6.0 SWITCHGEAR COMPONENTS:

6.1 **Circuit Breakers:**

6.1.1 Circuit breakers shall be Vacuum type.

6.1.2 CB Interrupter shall be leak free designed for 20 years of life service. All circuit breakers shall be C2 - M2 class as per IEC 62271-100.

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6.1.3 The breakers shall have at least 4 normally open (NO) and 4 normally closed (NC) spare auxiliary contacts for purchaser's use. If these are not available, auxiliary relays shall be used to multiply the auxiliary contacts of the breakers.

6.1.4 The breakers shall have a motor-operated, spring-charging mechanism. It shall also be possible to charge the springs manually and also a shrouded push- button for mechanical tripping initiation.

6.1.5 Breakers shall be trip-free and shall have an anti-pumping device. The mechanism and its control scheme shall be such that the mechanism shall not make repeated attempts to close the circuit- breaker when the control switch is held in the CLOSE position in the event of failure to latch on the first closing attempt or in the event of a trip signal being given to the circuit-breaker.

6.1.6 Trip and close shall be provided to meet the functional requirement. In addition, a manually operable local trip push-button (mechanically working onto the trip shaft) shall be available. The breakers shall be suitable for remote control. Manual, mechanical ON-switching shall be allowed only if interlocks have been satisfied. It shall be possible to lock each local control function when circuit breaker is in the open position. Operation counters of non resettable type shall be fitted to all circuit-breaker mechanisms.

6.1.7 The breaker enclosure shall have provision for easy withdrawal of the interrupter assemblies. This procedure shall not involve the removal or dislocation of adjacent bay enclosure parts. Checking the contact condition of the interrupter elements must be possible without disturbing any other gas compartment. Safe replacement of breaker interrupters must be possible while the remaining switchgear is "live".

6.1.8 The capacitive current switching, line charging and cable charging current, restrike performance, mechanical and electrical endurance, making and breaking current etc. shall be as per IEC 62271-100.

6.1.9 The electrical closing and tripping devices, including direct acting solenoid coils shall be capable of operation within the specified auxiliary voltage range.

6.1.10 A mechanical indicator shall be provided to indicate the status of the spring. The indication shall be visible with the doors of the mechanism cabinet closed.

6.1.11 The breaker main contacts shall be of copper with silver plating and shall have ample area and contact pressure for carrying the rated current and the short time rated current of the breaker without excessive temperature rise which may cause pitting or welding. Contacts shall be adjustable to allow for wear, easily replaceable and shall have a minimum of movable parts and adjustments to accomplish there results. Main contacts shall be the first to open and the last to close so that there will be little contact burning and wear.

6.1.12 The breaker arcing contacts, if provided, shall be the first to close and the last to open and shall be easily accessible for inspection and replacement. Tips of arcing and main contacts shall be silver faced or have tungsten alloy tripping. Provision shall be made for rapid dissipation of heat generated by the arc on opening.

6.2 **Vaccum Circuit Breakers:**

6.2.1 Circuit breakers employing the vacuum interruption principle shall incorporate vacuum bottles of established manufacturer. Full instructions for monitoring the state of vacuum and contact life shall be provided.

6.2.2 Vacuum circuit breakers shall be designed to have low switching-over voltage levels and with a long switching life. The interrupter shall be leak-free. Each interrupter shall be capable of individual adjustment for correct operation and easy removal for maintenance or replacement

6.3 **Operating Mechanism:**

6.3.1 Circuit breaker shall meet the duty requirements for any type of fault or fault location, also for line charging and dropping and perform make and break operations as per the stipulated duty cycles satisfactorily. The CB shall be suitable for carrying out the duty cycle of 0-3.0 minutes -CO-3.0 minutes -CO.

6.3.2 Main poles shall operate simultaneously. There shall be no objectionable rebound and the mechanism shall not require any critical adjustment. It shall be strong, rigid, positive and fast in operation. Main poles

of the breaker shall be of such design to ensure that the difference in the instants of closing and opening is minimal.

6.3.3 The design of the circuit breaker shall be such that contacts will not close automatically upon loss of gas pressure.

6.3.4 Electric power operating mechanism shall be motor wound spring charged stored energy type. The manual-operating mechanism may be of the spring charging stored energy type or spring assisted type. Provision shall also be made for manual spring charging.

6.3.5 The stored energy operating mechanisms shall be equipped with the following features:

i) Failure of springs, vibrations or shocks shall not cause unintended operation of breaker or prevent intended tripping operation.
ii) Closing of circuit breaker shall be prevented unless the spring is fully charged. It shall be necessary for the spring to be fully charged and the associated charging mechanism fully prepared for closing before it can be released to close the circuit-breaker.
iii) The closing spring shall get re-charged (for subsequent closing) soon after a closing shot and prior to breaker tripping. In case the limit switch fails to cut out the spring-charging motor with the springs fully charged, the motor shall be automatically de-coupled.
iv) If the circuit breaker is opened and the springs charged, then circuit breaker can be closed and then tripped.
v) If the circuit breaker is closed and the springs charged, there shall be sufficient energy to trip, close and then trip the circuit breaker.

6.3.6 All electrical power operating mechanisms shall be suitable for remote operation and shall be equipped with following features:

i) Provided with motor operable on AC or DC control supply as specified. The motor shall be protected against over current and short circuit.
ii) Provided with emergency manual charging facility. The motor shall be automatically, decoupled (mechanically) once the manual-charging handle is inserted.
iii) Closing operation shall be completed once the closing impulse is given and the first device in the control scheme has responded even though the control switch / Push Button is released, provided no counter trip impulse is present.

6.3.7 The close and trip circuits shall be designed to permit use of momentary-contact switches and push buttons. The trip coil shall be suitable for trip circuit supervision during both open and close position of breaker.

6.3.8 Auxiliary switches / contacts shall be provided in circuit-breaker tripping circuits to interrupt the tripping supply as soon as the circuit- breaker has completed the tripping operation, and to interrupt the closing supply as soon as the circuit breaker has completed the closing operation.

6.3.9 It shall not be possible to lock mechanically the trip mechanism so as to render inoperative the electrical tripping. Where earthing through the circuit breaker is adopted the method of earth position selection shall be arranged to disconnect the trip supply in the earth position.

6.4 **Disconnectors & Earthing switches:**

6.4.1 General

i) Disconnectors shall be of single-pole, group operated type and installed in the switchgear to provide electrical isolation with one motor operated mechanism for three poles. The disconnectors shall conform to IEC- 62271-102.
ii) Motor operable on AC or DC control supply as specified shall be provided. The motor shall be protected against over current and short circuit. Power operated drive provided shall be suitable for local & remote operation and also fitted with an emergency operation facility.
iii) The disconnectors 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.
iv) The actual earthing of the feeder / bus-bar shall be done via the circuit breaker, i.e., where the disconnector is used only to preselect the earthing position. The three way switch provided must

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have definitive stops at their "ON", "ISOLATED" and "EARTHED" positions, with no direct movement from the "ON" through the "ISOLATED" into the "EARTHED" position.

v) Mechanical indicators connected directly and permanently to the operating shaft are required to positively display the actual disconnector position. Indirect position indicators are not acceptable.

vi) When C.B. is used for earthing, means other than locking shall be provided to ensure that the electrical tripping at the C.B. is rendered inoperative when closed.

6.4.2 Constructional features

i) The disconnectors shall be provided with high current carrying contact surfaces made of silver faced copper/silver faced aluminium.

ii) Arrangement shall be provided to permit manual operation of the disconnectors. Whenever the manual handle is inserted into the drive mechanism, it shall not be possible to control the device electrically. Manual operating handle will be provided with pad lock. The contacts shall be both mechanically and electrically disconnected during the manual operation.

iii) 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.

iv) The disconnectors and earthing switches shall have a mechanical key (pad locking key) and electrical inter-locks to prevent closing of the earthing switches when isolator switches are in the closed position and to prevent closing of the disconnectors when the earthing switch is in the closed position.

v) The disconnector switches shall be capable of being padlocked in both the fully open and fully closed positions with the operating motor automatically disengaged. The padlock must be visible and directly lock the final output shaft of the operating mechanism. Integrally mounted lock can also be provided instead of padlock.

vi) For safe isolation and earthing of the busbars and feeders, high speed fault-making spring driven earth switches shall be provided. The contacts shall have the same fault making capability as that of the circuit breaker. As an alternative to the fault making earthing switches, circuit breakers may be used for the earthing, of the outgoing feeders and busbars.

vii) Motor-operated combined disconnector / earthing switches, interlocked with the breaker by suitable electrical and mechanical interlocks, shall be provided.

6.5 **Instrument Transformers:**

Current and voltage transformers shall be cast-resin insulated. The primary and secondary terminals shall be marked indelibly and easily approachable for termination and testing etc. All transformers must be suitable for continuous operation for 20% overload and for service under all rated and fault conditions.

6.5.1 Current Transformer

i) Current transformers shall conform to IEC 61869 -1&2 / IS: 2705. The short-time rating shall be equal to that of the switchgear. They shall be Toroidal /ring core of the vacuum-potted epoxy type. The CT ratings shall be as shown in the data sheet. Protective CTs shall have an accuracy class of 5P and an accuracy limit factor greater than 10. CTs for instruments shall have an accuracy class of 1.0 and an accuracy limit factor less than 5.0. For numerical relays having protection and metering functions, dual rated CT shall be provided suitable for protection class and metering class. Separate CTs shall be provided for Differential and Restricted Earth fault protection. One leg of the CTs shall be earthed.

ii) Where multi-ratio secondary windings are specified a label shall be provided at the secondary terminals of the current transformer indicating clearly the connections required for each ratio. These connections and the ratio in use shall also be shown on the diagram of connections.

iii) A11 CTs shall be star connected. Interposing CT (ICT) shall be provided (if required) for differential protection of transformers having star-delta connection.

iv) Proper access to each set of CTs shall be provided for repair / maintenance. The CT rating plate and the terminals must be accessible after the Power cables have been installed. The current transformer particulars as specified in relevant IEC shall be given on an accessible plate mounted external to the current transformer.

v) The polarity of the primary and secondary windings of each current transformer shall clearly be indicated.

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6.5.2 Voltage Transformer

i) The voltage transformers shall conform to IEC 61869-1&3 / IS: 3156. Voltage transformers shall be of the electromagnetic type. The earth end of the high voltage winding and the ends of the secondary winding shall be brought out in the terminal box. The voltage transformers shall be provided with 4 pole miniature circuit breakers with auxiliary contacts on the secondary side.

ii) The primary connection shall be disconnected before the VT becomes accessible. Neutral point of the star connected VTs both on the primary and secondary sides shall be earthed.

iii) The VTs shall have an over-voltage factor of 1.9 for 30 seconds, and an accuracy class of 1.0 from 10% to 120% of normal voltage. VT selected shall be compatible with system earthing. Whenever VT secondary is used for both measurement and protection application, it shall have dual accuracy class of 0.2 / 1.0 unless otherwise specified.

iv) Enclosures of voltage transformers shall be earthed and completely safe to touch during operation. Voltage transformers must be able to withstand the full rated power frequency withstand and BIL voltages.

v) Electro-magnetic VTs shall be capable of discharging the capacitance of lines, cables and Switchgear which may remain connected to them during switching operations.

vi) Voltage transformers shall be protected on the HV side by high rupturing capacity, short circuit current limiting fuses in accordance with IEC 60282-1. Fuses shall be readily accessible.

vii) It shall be possible to isolate the voltage transformer without de-pressuring any gas filled compartment.

6.6 **Low voltage Equipment, Control & Protection Circuits:**

6.6.1 All low voltage equipment shall be installed in a separate metal-enclosed cabinet with a separated access door and one terminal strip for all field connections. The minimum required indication and protection devices shall be as per and single line diagram and technical specification(PY55294 and annexures). The cabinet shall have door limit switches and panel illumination.

6.6.2 Relays

i) Protection relays shall be numerical type as specified on the switchboard SLD. All other relays shall be electromagnetic type.

ii) All electromechanical protective relays shall be back-connected, of drawout type, suitable for flush mounting, and fitted with dust-tight covers. Alternatively, "plug-in" type relays will also be acceptable. Auxiliary relays are acceptable in fixed execution.

iii) The protective relay cases shall have a provision for insertion of a test plug at the front for testing and calibration using an external power supply without disconnecting the permanent wiring. The insertions of the test plug shall automatically short circuit the CTs and permit extension of external power supply to the relay.

iv) All protective relays shall have hand reset facility and clear operating indication, e.g. flags for electro-mechanical type relays or light emitting diodes for static/numerical type relays. It shall be possible to reset the flag without opening the relay case.

v) All tripping relays shall be of lockout type with hand-reset contacts, and shall be suitable to operate on the specified voltage. These relays shall have self coil cut off contacts, and shall be provided with hand-reset operation indicators.Tripping relays will be acceptable in non-drawout cases.

vi) The tripping relay shall be suitable for satisfactory operation from 50% to 110% of the specified control supply voltage.

vii) Numerical relays shall be equipped with communication port to work as an integrated part of the substation automation system. Multifunctional device (bay control and protection unit) shall be with control, indication, metering, Protection, mimic, Communication / interface Functions.

viii) Numerical relays shall be as per PY55294, Annexure-2A, data sheet and relevant annexures.

6.6.3 Control and Indication

6.6.3.1 Each control circuit shall be protected by a two-pole miniature circuit breaker with auxiliary NC contact. The auxiliary contacts of all MCB's of the same circuit type, e.g., breaker motor control, disconnector switch motor control, alarm, space heater, trip, etc., shall be wired in series to a group / common alarm terminal.

6.6.3.2 Each circuit-breaker shall be provided with local control facilities including local control switches and a mimic diagram for the operation and status indication of the circuit-breaker and all associated disconnectors and earth switches together with control/selector switches.

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6.6.3.3 Breaker tripping, closing and spring charging devices shall be fed with DC control power supply. The rated DC voltage shall be as specified in the data sheet. The power supply for breaker opening, closing and indication devices shall be arranged as follows:

i) One DC feeder shall be provided for each bus section. The bus coupler panel may be fed from any of the two supplies.

ii) One separate, single-phase power supply shall be provided for each bus section for feeding space heaters, etc. Supply voltage shall be 240 V AC, unless otherwise specified.

6.6.3.4 Provision to receive DC and AC control supply shall preferably be provided in bus-coupler panel / bus VT panel.

6.6.3.5 Completely separate and isolated circuits shall be used for Switchgear control, tripping / protection, alarms, and auxiliary devices. These circuits shall have separate control power buses and feeders, suitably protected, for each power bus section.

6.6.3.6 Breaker positions (CLOSE, OPEN, spring-charged) shall be indicated mechanically. Electrical indications (minimum) with colours as given below shall be provided :

i) Breaker 'CLOSE' :Red Lamp
ii) Breaker 'OPEN' :Green Lamp
iii) Breaker Auto-Trip :Amber Lamp
iv) Trip Circuit Healthy :White Lamp
v) Spring Charging :Blue Lamp
vi) Earth Switch Close :White Blinking Lamp
vii) Disconnector Close :Red Lamp
viii) Upstream Breaker ON :Red Lamp (For incomer)
ix) Upstream Breaker OFF : Green Lamp (For Incomer)

6.6.3.7 Clustered LED type indicating light with minimum 8mm diameter size shall be provided for indications. The LED shall have a low glow voltage protection and shall not glow on voltage leakage.

6.6.3.8 A common DC control supply fail indication shall be provided for each bus section with a blue coloured lamp.

6.6.3.9 Mechanical Indicators mounted external to the equipment shall be provided on all circuit breakers, disconnectors and earth-switches, which shall clearly show whether the disconnectors/ CBs / earth switches etc. 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 in the vicinity of the equipment.

6.6.4 Auxiliary Equipment

6.6.4.1 Auxiliary Relays and Contactors

i) Auxiliary relays and contactors shall generally be used for inter-locking and multiplying contacts. Auxiliary contacts shall be capable of carrying the maximum anticipated current.

6.6.4.2 Control Switches

i) All control switches shall be rotary type, having a cam-operated contact mechanism otherwise stated. Circuit breaker control switches shall be 3-position CNT, spring return to neutral from both Close and Trip positions. They shall have pistol-grip handles.

ii) The Local/off/remote switch shall be three positions type, lockable, key free in remote positions only with the following functions:
- Local position (the breaker, disconnector and earthing switches can only be operated locally by its control switches).
- Off position (the breaker, disconnector and earthing switches cannot be operated electrically).
- Remote position (the breaker and disconnector can only be operated from Remote).

iii) Breaker / disconnector / earthing switch ON / OFF control switches (separate from Bay Control Unit) shall be provided.

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iv) Ammeter selector switches shall have a make-before-break feature on its contacts. The selector switch shall generally have four positions, three positions for reading 3-phase currents and the fourth position for OFF. The voltmeter selector switch shall also have four positions, three positions shall be used to measure phase-to-phase voltages and the fourth position shall be for OFF.

6.7 **Voltage Detectors:**

Each outgoing & incoming feeder shall include voltage detectors to indicate phases "AL1VE". The voltage detectors shall be connected to each phase on the cable side. The unit shall also be suitable for interlocking of earthing switches (voltage free condition).

6.8 **SF6 Gas Handling Unit:**

6.8.1 Portable SF6 gas handling & processing unit suitable for evacuating, liquefying, evaporating, filling, drying and purifying SF6 gas during the initial installation, subsequent maintenance and future extension of GIS shall be provided. The cart shall be equipped with rubber wheels and shall be easily maneuverable within the building.

6.8.2 The unit shall be self-contained suitable for 415 V AC, 3-phase, 50 Hz power supply and fully equipped with an electric vacuum pump, gas compressor, gas drier, gas filter, refrigeration unit, evaporator, gas storage tank, full instrumentation for measuring vacuum, compressor inlet temperature, tank pressure and temperature, valving and piping to perform the following operations as a minimum requirement:

- Evacuation from a gas filled compartment using the vacuum pump,
- Transfer of SF6 gas from a system at some positive or negative pressure to the storage tank via the gas drier and filter;
- Recirculation of SF6 gas in the storage tank through the drier,
- Recirculation of SF6 gas in any Switchgear or bus duct compartment through the drier and filter;
- Evaporating and filling SF6 gas,
- Drawing off and liquefying SF6 gas,
- A combination operation of filling SF6 gas into a gas system and evacuating a second, gas system using the vacuum pump.

6.8.3 Adequate length of hoses shall be provided for filling of SF6 gas in any of the gas compartment with the help of gas cart.

7.0 INSPECTION TESTING AND ACCEPTANCE:

7.1 **General**

7.1.1 Vendor shall have valid type test certificates to verify the making and breaking capacity of the switching devices & other primary components and other test certificates as per relevant IEC standard.

7.1.2 During fabrication, the switchgear shall be subject to inspection by EIL / Owner, or by an agency authorized by the Owner, to assess the progress of work, as well as to ascertain that only quality raw material is used. The manufacturer shall furnish all necessary information concerning the supply to EIL / Owner's inspectors.

7.1.3 All switchgear components (CBs, disconnector, earthing switches etc.) shall be tested in accordance with the latest relevant IS, IEC Standards (as minimum requirement). Test certificates for each switchgear component shall be submitted prior to delivery.

7.1.4 All shop/Routine test shall be witnessed by an inspector of EIL/BHEL/Owner, prior notice of minimum 2-weeks shall be given to the inspector for witnessing the tests.

7.2 **Factory Tests**

7.2.1 Type Tests:

7.2.1.1 The switchgear should have been subjected to all type tests at an internationally recognized testing station or an independent test laboratory. The vendor shall also submit type test certificates covering the offered switchgear components.

7.2.1.2 Type tests certificates / reports shall be considered acceptable if they are in compliance with the latest applicable relevant Standards and conducted at recognized laboratory.

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7.2.1.3 If the presented type test reports are not in accordance with the above requirements, Owner/EIL reserves the right to ask for the type tests to be repeated in the manufacturer's premises or other recognized places at no additional cost. The recognized laboratory shall issue the relevant type test certificates upon successful test.

7.2.1.4 The vendor shall have valid type test certificates for following :

i) Dielectric tests
ii) Temperature rise test
iii) Internal arc test
iv) Making and breaking tests
v) Short circuit duty test and Short time withstand test (Peak and 1 sec. withstand) on switchgear for intended application.
vi) Operation and mechanical endurance tests
vii) SF6 gas leakage test for ensuring 0.25% leak rate verification.
viii) Power frequency withstand test on panel
ix) Impulse withstand test on panel
x) Test to verify pressure relief devices operation of the panel at 40kA.This shall be done on one panel in each individual HT chamber. Type test for internal Arc shall be in according to IEC 62271-200/100
xi) Type test report applicable for Disconnector and earthing switch shall be furnished separately.

7.2.2 Routine Tests:

7.2.2.1 Switchgears and their components shall be subjected to routine tests as per the relevant IEC standards.

7.2.2.2 Routine test certificates shall be submitted for EIL/Owner's review and approval before shipment of the switchgear components.

7.2.2.3 The routine tests for the switchgear shall also include the functional tests for the associated low voltage compartments.

7.2.2.4 The following tests shall be performed as bare minimum as routine tests in addition to the standard tests:

i) Speed and timing tests for circuit breakers
ii) Partial discharge measurements
iii) Primary injection test for all current and voltage transformers
iv) Secondary injection tests for all protection relays.
v) Functional Tests for all components and for all panels, including Protection and interlocking functionality, inter-tripping, mechanical and electrical operations, etc.
vi) Tests on Auxiliary and Control Circuits
vii) Measurement of the Resistance of the Main Circuit
viii) Tightness Test
ix) Design and Visual Checks
x) Insulation resistance testing

7.2.2.5 Only fully wired panel integrated along with CB , disconnector and other HT parts shall be inspected at manufacturer works.

7.2.2.6 The following acceptance tests shall be carried out at the manufacturer's works under his care and expense.

i.A general visual check shall be carried out . this shall cover measurement of over all dimensions, locations, number and type of devices, location and connection of terminals etc.(equipment verification test)
ii. Manual and electrical operation of circuit breakers and relays shall be checked under worst condition of auxiliary supply voltage.
iii.Dry insulation test with power frequency voltage shall be conducted for the main and auxiliary circuits.
iv.Insulation resistance of the main and auxiliary circuits shall be checked before and after power frequency voltage withstand test.
v.Operation check shall be carried out for every control function as per approved schematic diagrams by manually simulating fault conditions and operation of control switches, relays etc.

7.2.2.7 For equipment bought from other sub suppliers, certified test reports of the tests carried out at the manufacturer's works shall be submitted. Normally all routine tests as specified in the relevant standards shall be conducted by the sub-supplier at his work.

8.0 PACKING AND DISPATCH:

8.1 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 for any damage during transportation, transit and storage.

8.2 The SF6 equipment shall be shipped in the largest factory assembled units within transport and loading limitations and considering handling facilities on site 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.

8.3 Each individual piece to be shipped, whether crate, container or large unit, shall be marked special notations such as `Fragile', `This side up', `Center of gravity', `Weight', `Owner's particulars', `PO no.' etc., and other details as per purchase order.

8.4 The equipment may be stored outdoors for long periods before installation. The packing shall be completely suitable for outdoor storage in areas with heavy rains and high ambient temperature.

8.5 Special precautions shall be taken to protect any parts containing electrical insulation against the ingress of moisture. All blanking plates, caps, seals, etc., necessary for sealing the gas sections during shipment to site shall be provided. All parts liable to rust shall receive a coat of anti-rusting composition and shall be suitably protected

8.6 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.

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