TECHNICAL SPECIFICATION

500kV SF6 GAS INSULATED SWITCHGEAR, CIRCUIT BREAKER INCLUDING OUTDOOR GAS INSULATED BUS DUCT

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1.01 Scope

This Standard Specification specifies the minimum technical requirements for design, engineering, manufacture, inspection, testing and performance of SF_6, gas insulated metal-enclosed switchgears (GIS), to be installed indoors (with or without having outdoor terminations and associated exit bus ducts) in the 500kV, intended to be used in the system of the K-Electric Pakistan.

he latest revision/amendments of the Codes and Standards shall be applicable for the equipment/material

1.02 DESIGN AND CONSTRUCTION REQUIREMENTS

GENERAL

1.02.1 The Gas Insulated Switchgear (GIS) shall be a complete unit comprised of main equipment, all control, monitoring, protection, measuring and auxiliary devices and systems including interconnections, all termination joints at interfaces, mechanical linkages, couplings, SF6 gas piping, cabling, wiring, grounding materials etc. required for proper and satisfactory operation.

1.02.2 The GIS shall be:

a. Of compact and modular design with individual equipment modules connected together to form a complete assembly, with ample space in between each bay for maintenance purposes. However, combined disconnect switch and grounding switch, cable termination, VT, exit bus duct and CT (with cores located within gas compartment) shall be in separate gas tight compartment. If, CT is installed in breaker gas compartment; insulation class for CT shall be class F.

b. Of single-phase enclosure type for voltage level of 500kV.

c. Installed on suitable pads or supporting frames/structures with provision for leveling, including fasteners to foundation, which shall also be included in the supply. Support-structures shall be designed and fabricated to withstand the short circuit forces of the ground fault current.

d. Having expansion joints and flexible connections, where several

enclosures are connected in the longitudinal direction, such as main bus. Expansion joints provided for installation alignment shall be locked in place when alignment is complete. Expansion joints for compensation of thermal expansion and erection tolerances shall have the means to preserve mechanical integrity of the enclosure and the plug-in contacts for the conductor.

e. Provided with galleries, stairways, movable platform or walkways for accessing the equipment above two meters for maintenance and operation. All structures, movable platform, galleries, stairways and walkways shall have grounding provision and shall conform to the relevant Occupational Safety and Health Administration (OSHA) regulations.

1.02.3 For single-phase type GIS, creation of single gas zone by external connection between the phases is not acceptable. Also, external piping connection (with normally open valve) to create common gas zone (between same phase) in single-phase type GIS is not acceptable.

1.02.4 The GIS enclosure shall be safe to touch and fully ensure operational security and personnel safety under all normal and fault conditions with the maximum allowed induced voltage in the enclosure of 65 volts.

1.02.5 The switchgear and all its components and accessories shall be designed for minimum maintenance during service. The manufacturer shall state the minimum interval between minor inspections (which will be restricted to visual checking and adjustments of external parts only) and major inspection/overhaul, including refilling or replenishment of gas and cleaning of the contaminant or filter in the circuit breaker chamber(s). Suitable openings shall be provided in the circuit breaker, disconnect and grounding switch modules for major inspection/adjustments. All motors shall be in accordance with IEC 60034. The bearings and other such parts shall be permanently lubricated for the entire service life. Padlocks shall be made of stainless steel or brass.

1.02.6 The GIS interface points shall be carefully coordinated with other equipment such as overhead lines, cables, transformers, reactors, capacitor banks, etc., supplied by other manufacturers in order to ensure full compatibility. The design criteria for outdoor portion of the GIS bus duct leading to SF_6-to-Air Bushing for connection with 500kV lines and transformers connection shall be as mentioned in clause 8.18. and in the data schedule.

1.02.7 All modules of the switchgear and components of the same rating and

construction, which may need to be replaced, shall be strictly interchangeable.

1.02.8 The degree of protection for all terminal boxes and operating mechanism enclosure shall be IP54 per IEC 60529.

1.02.9 To facilitate transport and handling, lifting eyes or other suitable attachments shall be provided with each GIS module.

1.02.10 Each module of switchgear, consisting of individual elements intended to be directly connected together, shall be constructed as a transportable assembly suitable for shipping and transportation without being dismantled.

1.02.11 All new gaskets, sealants and desiccants for permanent sealing of all field joints and all access covers, removed during assembly, shall also be provided.

1.02.12 The GIS shall be designed per IEC 62271-203 or ANSI/IEEE C37.122 standard. The enclosure shall be capable of sustaining without damage all mechanical, electrical and thermal shocks that may occur in service during normal and fault conditions, including pressure effects of internal fault arc current of specified short circuit level and time. The enclosure assembly, material and design shall be such as to minimize induced electrical losses and heating effects which could occur in service under normal and fault conditions.

1.02.13 Joints and couplings between dissimilar metals shall be avoided to prevent galvanic corrosion.

1.02.14 All supporting steel work shall be hot-dip galvanized.

1.02.15 A partition separating a compartment filled with insulating gas from a neighboring compartment such as a cable box, filled with liquid, shall not show any leakage affecting the dielectric properties of the two media.

1.02.16 All welding in GIS shall conform to Section IX of ASME code or equivalent. The number of welds shall be kept to a minimum. At least 10% of all welds must be subject to non-destructive testing by X-ray or ultrasound and all records of these must be made available.

1.02.17 The construction and thickness of the GIS enclosure and energy stored spring charge operating mechanism shall confirm to ANSI/ASME Boiler and Pressure Vessel Code, and ANSI/ASME B31.1 or equivalent.

1.02.18 All current carrying parts shall be made of electrolytic grade copper or aluminum alloy. All interconnecting sections of current transferring parts shall be silver-plated.

1.02.19 All piping for SF6 gas and spring charge operating mechanism including their fittings shall be made of copper, brass or stainless steel.

1.02.20 All external connectors and terminal pads shall be made of copper or aluminum with tin-plating and designed per NEMA CC1 and NEMA CC3. Terminal pads shall have 4 holes.

1.02.21 Each circuit breaker, disconnect and grounding switch shall be provided with mechanically driven auxiliary switches. These auxiliary switches shall be provided with minimum six (6) normally open (NO) and six (6) normally closed (NC) spare auxiliary potential-free contacts preferably convertible at site in addition to those required for the operating mechanism control and indications, protection and interlocks with other equipment. Rated interrupting current of the auxiliary contacts shall be not less than $10A_{dc}$.

1.02.22 The SF6 gas tight barriers in the GIS bays (the left and right extreme bays) shall be such that future extension in the GIS would not require shutdown of the GIS bay.

1.03 RATINGS

1.03.1 The specific ratings of the GIS equipment shall be 4000Amp at 70 deg C

1.03.2 The switchgear shall be capable of carrying the specified rated current continuously at the design ambient and specified ambient conditions in Design parameters SCC, without temperature rise of various parts exceeding the limits stated in IEC 60694 or equivalent ANSI standards. The maximum temperature of the external surfaces of GIS enclosure, normally handled by an operator, shall be 70°C for outdoor portion and 55°C for indoor area.

1.03.3 The maximum noise level produced by switchgear and its associated apparatus during service shall not exceed the values specified in the data schedule.

1.03.4 All equipment and components of the switchgear including bus support insulators shall be free of partial discharges when operated at the rated

voltage. The partial discharge intensity at 110% rated voltage shall not exceed 10 pC with a maximum background level of 5pC.

1.03.5 The insulation level requirements shall be as specified in S/S design parameters Section.

1.03.6 The Circuit Breakers shall be rated conforming to the requirements of latest edition of IEC 60056 and IEC 60694 except as other-wise specified herein and as follows:

		Required	Tendered
(1)	Nominal system voltage, kV, rms	500	
(2)	Rated voltage, (Ur) kV, rms	550	
(3)	Rated insulation level:		
	(a) Rated one minute power frequency, withstand voltage, kV, rms.		
	- Phase to earth and between phases	740	
	- Across open breaker	910	
	(b) Rated lightning impulse withstand voltage, kV, peak.		
	- Phase to earth and between phases.	1550	
	- Across open breaker	1550 (+315)	
(4)	Rated normal frequency, Hz.	50	
(5)	Rated current at 50 Hz and 50 deg.C. not less than, A.	4000	
(6)	Rated short-time withstand current, kA, rms	63	
(7)	Rated peak withstand current, kA, peak.	157.5	
(8)	Rated duration of short circuit, second	1	

(9)	Rated short-circuit breaking current at rated voltage and 50 deg. C, not less than kA, rms.	63
(10)	Percentage of DC component, %.	40
(11)	Rated short-circuit making current, kA, peak.	157.5
(12)	Rated operating sequence	O-0.3sec-CO-3min-CO
(13)	Rated out-of-phase breaking current, kA, rms	10
(14)	Rated line charging breaking current, A	500
(15)	Rated cable charging breaking current, A	500
(16)	Rated break time, ms.	40
(17)	Visible or audible corona (1.1 xUr/√/3) kV, rms, line to ground, 50 Hz	None
(18)	First pole-to-clear factor	1.3
(19)	No of breaks per pole	minimum 2
(20)	Percentage of spare auxiliary switches:	
	- Normally open	25%
	- Normally closed	25%

21	Maximum guaranteed switching over voltage to earth,kV	876/3 p.u (at T60)
22	Rated small inductive breaking current,A	0.5-20 A at 2.5p.u
23	Rated transient recovery voltage for terminal faults (for 2.0/micro sec,rate of rise),kV, and 100%)	IEC 817 (T100s: dc:<20%) acc.IEC

C.	**Time Characteristics at Rated control Voltage and Operating Pressure**	
1	Lack of simultaneity between any two of the three poles:	
	a) At contacts opening, msec.	4 ms
	b) At contacts closing, msec.	5 ms
2	Maximum closing time (from energization of closing control to completion of closing stroke) msec.	85 ms
3	Maximum opening time (from energization of trip control to contract parting) msec.	35 ms
4	Maximum arc duration:	
	a) Without current, msec	18 ms
	b) At 100% of rated breaking current, msec	18 ms
5	Current on which maximum arc duration occurs (critical current), A.	
6	Rated maximum break time, msec.	
	a) for 25 – 100 percent of the required rated breaking current.	52 ms
	b) for below 25 percent of the required rated breaking current	52 ms
7	Time from contact touch to contact part on Close – Open operation, msec.	max. 45 ms
8	Minimum time from arc extinction to contact remake for auto-reclosing (dead time), msec.	324 ms (dead time)
9	Number of single short auto-reclosing duties allowable before maintenance lockout	
10	Rated reclosing time, msec	300 ms (open-close time)

11	Rate of rise of recovery voltage at terminal faults:	
	a) 100% fault duty, V/microseconds	acc. IEC
	b) 60% fault duty, V/microseconds	acc. IEC
	c) 30% fault duty, V/microseconds	acc. IEC
	d) 10% fault duty, V/microseconds	acc. IEC
12	Rate of rise of recovery voltage (line side) at rated breaking current with fault at critical distance, V/micro – sec.	acc.IEC
13	Critical distance to fault, km.	acc.IEC
D	**Design and Construction**	
1	Type of main contacts	
2	Resistance drop across main contacts at rated current, millivolts	1.6mV at 100A (160 uohms)
3	Type of arcing contacts	
4	Does magnetic effect of load current increase contact pressure? (Yes/No)	No
5	Minimum electrical clearance between stationary and moving conducting parts when breaker is open, mm.	
6	Number of operations before contacts have to be changed when used to interrupt	>6000 at rated current
7	No. of operating mechanisms for 3 – pole circuit breaker	3
8	No. of breaks per pole	2
9	Length of break, mm	
10	Length of stroke of moving contacts	
11	Maximum time variation between:	

	a) The closing of contacts on any two phases, milliseconds	4 ms
	b) The opening of contacts on any two phases, milliseconds	5 ms
12	Material of conducting parts.	Copper Silver Plated
13	Is breaker suited for independent pole operation? (Yes/No)	Yes
14	Is breaker suited for high speed 3-Phase and single phase auto-reclosing? (Yes/No)	Yes
15	Does the breaker re-strike free? (Yes/No)	Yes
16	Whether trip free or fixed trip:	
	a) Electrically	Yes
	b) Mechanically	No
17	Maximum noise level at 1 meter horizontal distance at the perimeter of circuit breaker during opening and closing operations of three poles simultaneously, dB (A).	<=100dB
18	Provision of anti-pumping device	Yes
19	Is any devices used to limit transient recovery voltage? (Yes/No). If yes append detailed description.	No
E	**Other Data**	
1	Rated pressure of SF6 gas at 20 deg. C	7.0 bar (g)
2	Minimum pressure of SF6 gas at which rated BIL will be maintained, Mpa	6.2 bar (g) at 20C
3	Range of SF6 gas pressure at which breaker will operate satisfactorily:	
	a) Maximum MPa.	8.4 bar (g) at 20C

	b) Minimum, MPa	6.2 bar (g) at 20C
4	Maximum leakage losses of SF6 under site conditions, bar/year	< 1% per year
5	Total volume of SF6 gas per breaker, m3.	
6	No. of operations from SF6 stored at circuit breaker without recycling	Min 6000 at rated current
7	SF6 pressure at which:	
	a) Closing is blocked, MPa	6.4 bar (g)
	b) Tripping is blocked, MPa	6.2 bar (g)
F	**Operating Mechanism**	
F.1	**Common Data for energy stored Spring Operating Mechanism**	
1	Type of operating mechanism	
	a) Method of tripping	
	b) Method of closing	
2	No. of phases and voltage (AC/DC) of:	
	a) motors	220 V DC
	b) heaters	230 V AC
3	Power (AC/DC) demand of	
	a) motors	780 W
	b) heaters	Appr.200W per bay
4	Voltage range within which motor will operate satisfactorily	158V……246V
5	No. of trip coils per phase	2
6	Rated control voltage of:	

	a) Closing coil	220
	b) Tripping coil	220
7	Operated voltage range of:	
	a) Closing coil	+12……..-44%
	b) Tripping coil	+12……..-44%
8	Rated closing control current (total for 3 phases):	
	a) Initial	1.4 A per coil
	b) Holding	1.4 A per coil
9	Rated tripping control current per trip coil	1.4 A
10	Locked rotor and maximum running current required by motor operating mechanism at rated voltages.	15(starting current) / 5.5A
11	Heater capacity and characteristics:	
	a) Operating mechanism housing, watts	35W (motor, oil-tank, aux-switch)
	b) Control cabinet, watts	30W
	c) Other locations (specify), watts	
	d) Operating voltage, volts	230 V AC
F.2	**Data for Spring Operated Mechanism**	
1	Max. time for the motor to recharge the closing spring after a close-open operation, sec.	
2	Number of normally close contacts	8 free use
3	Number of normally open contacts	7 free use
4	Number of reversible contacts	1 wipe
5	Number of adjustable contacts	
6	Voltage rating of auxiliary contacts	250 V AC

7	Current rating of auxiliary contacts:	
	a) Making current	2 A
	b) Holding current	10 A
	c) Breaking current	2 A
8	Provisions available for SCADA and Remote Control functions (Yes/No)	YES

1.04 SWITCHING REQUIREMENTS

The switchgear shall incorporate single pressure, single/double break, puffer type SF6 gas-insulated circuit breakers suitable for single pole and triple pole rapid auto-reclosing. They shall generally comply with the requirements of IEC standards.

The interrupting chambers of the circuit breakers shall be equipped with separate over pressure relief and gas density monitoring devices. The gas in the interrupting chambers shall not be allowed to mix with gas in the breaker compartments or other adjacent modules.

In the interrupting chambers of the circuit breakers, suitable and permanently effective filters shall be installed to remove decomposition products due to arcing and other impurities in the SF6 gas.

All rated parameters of the circuit breakers including the breaking time shall be complied with at minimum permissible gas density and minimum specified D.C. control voltage.

The operating mechanism shall enable emergency manual operation of the breaker. Facilities shall also be provided for manual slow closing of circuit breaker for maintenance purposes.

The circuit breakers shall be provided with operation counters.

The circuit breaker shall be suitable for switching transmission lines for any type of fault. The Bidder shall be required to provide documentary evidence to prove that the offered circuit breaker(s) shall be suitable for transmission line switching.

The maximum noise level of the circuit breaker, when operated to close or open the three poles simultaneously shall be less than 140 dB(A) at 1 meter horizontal distance at the perimeter of circuit breaker with cabinet closed.

The circuit breaker shall be suitable to meet the requirements for full out-of-phase switching. The interrupting capability shall not be less than 25% of rated short circuit current at a voltage across one phase of value equal to two times the maximum rated phase voltage.

The circuit breaker shall be capable of handling the Short-line fault conditions associated with line switching in accordance with IEC Publication 60056.

1.05 OPERATING MECHANISM

The spring charge operating mechanism and appurtenances shall conform to IEC Standard Publication No. 60056. Each three pole breaker unit shall have independent control mechanism.

The circuit breakers equipped with spring charged operating mechanism shall be closed by the stored energy of charged springs. The mechanism shall be designed such that the failure of spring will not prevent tripping and will not cause tripping or closing. The energy stored in motor-compressed spring shall be sufficient for an open – close - open operation at rated short circuit current. The charging motor shall be direct current. The motor shall not require more than 15 seconds to recharge the closing springs after a close-open operation. Means shall be provided to prevent operation of the mechanism when maintenance work is being done.

The operating mechanism shall be capable of performing the duty cycle as specified in Clause 8.03 of these Technical Provisions.

Working parts of the mechanism shall be of corrosion resisting materials, and all bearings which require frequent greasing shall be equipped with pressure type grease fittings and shall be readily accessible without dismantling the mechanism or housings. The mechanism and control system shall be strong, robust, positive, fast and shall not have objectionable rebound or require critical adjustments or frequent maintenance.

The mechanism shall be designed so that the failure of any component will not prevent tripping if there is a tripping command, and will not cause tripping or closing when there is no control command.

Provision shall be made on the circuit breakers for the attachment of a device to record the operation of valves, contacts, etc., so that timing tests can be made to verify the sequence of operation as prescribed.

For purposes of inspection and adjustment, means shall be provided to permit local operation of the breaker, so designed that the contacts of the breaker may be operated slowly for adjustment.

Mechanical position indicator to indicate the position of each pole of the breaker shall be provided. Open position shall be indicated by using letter "O" with green colour as background while closed position shall be indicated by letter "C" with red as background colour. Separate operation counter shall be provided for each pole of the circuit breaker. Motor over-running indication feature shall be incorporated to signal the excessive running of the motor while overcharging of the spring.

1.06 PERFORMANCE REQUIREMENTS

1.06.1 Temperature Rise:

The temperature rise of any part of the circuit breakers shall not exceed the temperature rise limits specified in Table 3 of IEC Publication 60694. The reference ambient temperature shall be 50 degree C.

1.06.2. Voltage Equalization:

The voltage across series connected interrupting contacts of circuit breaker shall be made as nearly equal as economical design permits by shunting interrupting contacts with suitable capacitors.

1.07 CONTROLS AND AUXILIARIES

1.07.1 Tripping and Closing Requirements:

The circuit breaker closing and tripping circuits shall be rated for 220 V DC Electrical tripping facilities for the operating mechanism of each pole shall be duplicated to include, but not necessarily limited to the following

(1) Two electrically independent and identical trip coils for each pole of the breaker and arranged to minimize the probability of failure of one trip coil affecting the operation of the second trip coil.

(2) Two electrically independent and identical close coils for each pole of the breaker and arranged to minimize the probability of failure of one close coil affecting the operation of the second close coil.

(3) One electrically independent and identical sets of wiring, terminals and protecting equipment for connection to 220 V DC independent closing and tripping power circuits.

(4) Auxiliary switches and auxiliary circuits shall be capable of carrying at least 10 A continuously without exceeding the temperature limits specified in table 3 of latest IEC 60694, at temperature of 50°C ambient.

(5) The control system shall include circuit to trip the breaker by energizing both sets of trip coils if pole disagreement should occur and alarm shall be initiated in the control room. A timer shall be furnished in the control cubicle to permit allowable phase discrepancy condition during single pole auto-reclosing. The setting range of timer shall be between 0.5 seconds to 2.0 seconds.

(6) The closing device shall be capable of closing the breaker for any value of voltage between 85% and 110% of rated control voltage and tripping device shall be capable of tripping the breakers for any value of voltage between 70% and 110% of rated control voltage.

(7) Both the tripping and closing coils shall be fed from separate DC sources for increased reliability.

1.08 LAYOUT

The layout shall be such that:

a. Future alterations and extensions can be undertaken in either direction by GIS manufacturers other than the original manufacturer. Adequate provision (Gas tight barriers) shall be provided at the busbar ends to reduce the degassing requirement in case of future extensions. No devices shall be installed at the bus bar ends.

b. Maintenance or removal of a disconnect switch or circuit breaker will not involve removal from service of adjacent disconnect switch or main bus sections.

c. Adequate clearances around GIS shall allow free movement of SF6 gas service cart. Adequate clearances between adjacent bays for maintenance purpose.

d. Sufficient clearances around bushing for cable HV AC testing shall be provided.

1.09 INTERNAL FAULT AND PRESSURE LIMITING DEVICES

1.09.1 The effect of an arc shall be confined to the compartment in which it has been initiated and under no circumstances shall be allowed to spread out to adjacent compartments or other parts of the switchgear. The minimum burn-through time for the GIS enclosures shall be 300ms.

1. 09.2 The over pressure created by internal arcing faults shall in no case be allowed to exceed the withstand capability of the enclosure.

1. 09.3 Rupture discs/pressure relief devices shall be fitted in each gas compartment including GIS surge arrester to relieve over pressure created by internal arcing faults automatically and instantaneously. Vent deflector shall be fitted with each rupture disc/pressure relief device to eliminate hazards to personnel and other equipment due to escaping gases or vapors under pressure.

1.10 SF6 GAS SYSTEM REQUIREMENTS:

The Contractor shall supply all relays, switches and accessories to provide for fail-safe operation of the circuit breakers during conditions of low gas density. The density shall be sensed in two stages, the first stage indicating an alarm. The second stage shall prevent closing or tripping of the breakers in case the SF6 gas density is too low, for safety reasons, and shall also give annunciation on control board. The design shall ensure the identification of the breaker pole with low SF6 gas density. One temperature-compensated density meter for each pole of circuit breakers shall be provided properly enclosed in a suitable enclosure.

The SF6 gas sealing system must guarantee minimal leakage under extreme temperature conditions and effectively restrict the entry of moisture or other gases. Maximum permissible leakage rate shall be <1% per annum. The material used for sealing system shall not deteriorate due to the exposure of the gas, vapors, temperature variations and mechanical forces during the long-term service. Maintenance of the sealing system should generally be possible without dismantling the breaker pole and draining the SF6 gas. The breaker design shall prevent liquefaction and partial condensation of moisture of the insulating parts of the breaker operating mechanism and SF6 containers.

1.10.1 The SF6 gas shall conform to IEC 60376 or ASTM D2472.

1.10.2 The manufacturer shall provide the data regarding gas characteristics corresponding to the degree of deterioration beyond which treatment or replacement of gas would become necessary along with procedural instructions for gas treatment to restore original quality.

1.10.3 The GIS shall be fully gas tight. The sealing system shall also effectively ensure against the ingress of moisture, dust and other contaminants into gas compartments. All gas compartments shall contain suitable agent to absorb moisture and any other decomposition products of SF6 gas.

1.10.4 SF6 gas relative leakage rate of each gas compartment shall not exceed <1% per year.

1.10.5 The GIS enclosure shall be sectionalized for each equipment into modular units or compartments, separated by solid gas barriers with an effective sealing system. Each gas compartment shall be provided with the necessary piping and self-closing non-return valves to allow isolation, sampling, evacuation and refilling of SF6 gas can be carried out during normal operation of the switchgear without evacuation of any other section or loss of gas. Piping must not block manual mechanical operation of any equipment including, GIS switchgear, disconnector, earthing switch, Surge Arrestor, CT links, VT link etc.

1.10.6 Piping must not block manual mechanical operation of any equipment including, GIS switchgear, disconnector, earthing switch, Surge Arrestor, CT links, VT link etc.

1.10.7 Gas barriers and sealing systems shall have adequate mechanical strength to withstand the dynamic forces caused by short circuits, and effects of internal arc faults as well as maximum pressure differential that could exist between adjoining compartments, i.e. with full vacuum drawn on one side of the barrier and 1.5 times the operating pressure on the other side.

1.10.8 SF6 gas in each individual compartment shall be monitored by suitable temperature-compensated pressure gauges and two-stage temperature compensated pressure (gas-density continuous monitoring) switches/relays to monitor the loss of SF6 gas. The dial of the pressure gauges shall be graduated to read pressures and colored green, yellow and red to indicate normal, Alarm Stage I (or non-urgent) and Alarm Stage II (or urgent) pressure conditions. The gas-density monitors shall be capable of being calibrated with the monitored equipment in service. If the gas-density monitor has a visual indicator, it shall be readable from the ground. Each pressure relay shall be provided with two convertible potential-free auxiliary contacts for two-stage alarm initiation as mentioned below. These alarm contacts shall be wired to the annunciator in the respective GIS bay control cabinet.

Stage I: Alarm at 10% above minimum safe operating gas density (and block breaker closing) (Refill stage).

Stage II: Alarm in the event of gas density falling below the minimum safe operating limit (and block breaker tripping).

1.10.9 In the event of gas leakage, all parts of the switchgear in the affected compartment shall be able to withstand continuously the maximum rated voltage with SF6 gas at atmospheric pressure.

1.10.10 It shall be possible to test and replace each pressure gauge and the density switch/relay with the GIS in service.

1.10.11 The O-ring gasket shall be synthetic elastomeric type. The gasket shall resist oil and waste by-products of the SF6 gas decomposition. The gasket shall have minimum deformation in service life of GIS and also low gas and moisture permeability. Outdoor flange joints on exit bus duct (if any) shall have double 0-rings.

1.10.12 Gas leakage detectors as recommended by GIS manufacturer shall be provided.

1.10.13 The SF6 gas pressure/density monitors shall be preferably directly coupled to the gas compartment. Permanently fixed gas pipe work (if required) for SF6 gas pressure/density monitoring shall be installed. The design, material, specification and associated fittings for all gas pipe work shall be rated for operation under normal and fault conditions and shall form part of the switchgear assembly during all testing carried at the manufacturer's works and at site. The gas piping system, valves etc. shall minimize the possibility of accidental third party damage and eliminate the need to dismantle the pipe work during maintenance and/or removal of modules, other than the pipe work associated with the maintenance item.

1.10.14 At each gas compartment, provisions shall be made for connecting online moisture measurement instrumentation and the gas service cart. The moisture content in the gas shall not exceed 150ppmv (parts per million per volume) in circuit breakers, and 250ppmv in other equipments. Provision for disconnection of gas pipelines shall be incorporated. 100µm or smaller sintered stainless steel particle filter disk, suitable for pressure involved, shall be installed at the gas service connection.

1.10.15 Filters shall be inserted in all the gas compartments in addition to circuit breaker compartment. The static filters provided inside the high-voltage enclosure shall not be shipped already fitted, but packed separately in air-tight sealed tin-cans and marked conspicuously. The gas decomposition product filter shall be effective for the duration of time between major overhauls. SF6 gas filters shall be as follows:

a. For moisture (H_20): Desiccant material such as $A1_20_3$, also called drying agent. The recommended particle size is 2-5mm.

b. For gaseous arc byproducts: Molecular sieve with a pore size of 4A. Materials used for this purpose should not be regenerated.

c. For particles (generally dust residues) or solid arc byproducts: HEPA-type or equivalent filter to remove particles with a size larger than 1µm.

1.10.16 A colored diagram with legends showing various gas compartments, piping, interconnections, valves, orifices and isolations to prevent current circulation, necessary controls and monitoring systems etc. together with normal and alarm ranges shall be mounted near each control cubicle for ease of supervision.

1.10.17 The location of gas barrier insulators shall be clearly and permanently marked with yellow or orange color Solid Red line for Gas Barrier, and stripped Red line for semi-permeable membrane. on the finished external surface of the

GIS enclosures.

1.10.18 The switchgear assembly supplies shall include:

a. The initial complete filling of SF6 gas for the assembly, and in addition, any gas lost during installation and commissioning procedures.

b. An additional 10% supply of gas complete with containers and monitoring equipment for use during the warranty period.

1.10.19 Adequate arrangement for storage of SF6 gas adjacent to the installed switchgear assembly shall be provided.

1.11 Additional Requirements:

Additional requirements specified herein shall also be incorporated in the design by the Contractor. All circuit breakers shall be designed for closure and tripping by remote and local electrical controls. Local electrical control shall be by means of a local CLOSE-TRIP control switch. The control location shall be selected by a LOCAL-REMOTE transfer switch provided within the local control cubicle. The 'local' operation of the circuit breaker shall be possible only when associated disconnectors are open. A two position 'Maintenance OFF' switch shall also be provided for operating the breaker when it is under maintenance. This switch shall normally be in 'OFF' position. In Maintenance position, the breaker shall be locally operable provided the associated disconnecting switches are open. The breaker shall also be disconnected from the remote control and protection system when the switch is placed in 'Maintenance Position'.

Necessary provisions shall be made to exhibit indications in the control room when the LOCAL-REMOTE transfer switch is in the LOCAL position.

All output contacts including breaker auxiliary switch contacts shall be wired out to terminal blocks. The circuit breakers shall be mechanically and electrically trip free and have an anti-pumping feature.

1.12 Wiring and Terminal Blocks

1.12.1 All wiring between the switchgear assembly equipment and the control cabinets shall be installed in raceways or galvanized rigid steel conduits or flexible steel tubing with PVC jacket and do not obstruct the maintenance access to devices/operating mechanism. The conduits shall be installed and located so as to minimize the accidental damage and to eliminate the need to dismantle the conduits during maintenance and/or removal of modules, other than the conduit associated with the maintenance item. The conduit shall be terminated via metallic adapters to ensure grounding.

1.12.2 All raceways cable fills shall be per NFPA 70. The principles of control wiring practice in GIS with continuity of the shield from one element to the next shall be per IEC 60096-1. When a shielded control cable enters a control cabinet, the cable shield shall be terminated immediately on the control cabinet enclosure. Cable with extruded copper shield is preferable.

1.12.3 All CT secondary related circuits within the control cabinet. shall not be smaller than $4mm^2$ copper For SCADA digital and analog input signals, SOE, Annunciator and status/alarm signaling circuits wiring size . shall not be smaller than $1.5mm^2$ copper For SCADA Control Output Signals and all other circuits the wiring size shall not be less than $1.5mm^2$.

1.12.4 All CT secondary circuit wiring, external to control cabinet, shall not be smaller than $4mm^2$. All potential transformer wiring, external to control cabinet, shall not be smaller than $4mm^2$ copper. All wiring shall be heat resistant, rodent resistant and flame retardant, with maximum operating temperature of 90°C, insulation type SIS as listed in ANSI/NFPA 70 or approved equivalent and rated 600/1000V, stranded annealed copper conductor per ASTM B-8. All wires shall be adequately rated for thermal withstand of the short circuit currents in accordance with back-up tripping time.

1.12.5 Wiring between devices and terminal blocks shall be carried in troughs or in neatly formed packs, which shall be tied or otherwise secured at frequent intervals to prevent undue stress on equipment or connections. Connections across portions, which are hinged or otherwise movable, shall be made with flexible wires formed to distribute the bending stress. No wires shall be teed or jointed between terminal points.

1.12.6 All control and instrumentation cables shall be properly shielded per IEC 60096-1 or IEEE C37.122.1 in the 1-30MHz frequency range. The cable shield shall preferably be grounded to the enclosure through a coaxial-type shield bulkhead connector.

1.12.7 All circuit wiring shall be identified by a permanent marking at each termination per IEC 60445 or equivalent ANSI/IEEE standard with non-adhesive ferrule or plastic sleeve marker. Markers shall be of material that will not deform or deteriorate, and shall withstand the specified ambient temperatures. Trip circuits shall be provided with red ferrule at the terminal block.

1.12.8 Color-coding of control cabinet wiring shall be as follows:

a. All DC circuits: Red, Black

b. All CT circuits: Red, Yellow, Blue, Black.

c. All PT circuits: . Red, Yellow, Blue, Black.

d. All alarm circuits: All Control wiring to be of Black color

e. All grounding conductors: . Only Green with Yellow Stripes.

f. 3-phase, 4-core AC power circuits: red, yellow, blue, black (neutral).

g. 2-phase, 3-core AC power circuits: Red, Yellow, Black (neutral).

h. 1-phase, 2-core AC power circuits: red, black (neutral).

1.12.9 All terminal blocks, except electronic systems internal terminal blocks, shall be rated 600/1000V minimum, and shall have spring loaded type termination. Terminal blocks shall be clearly numbered and identified. The comparative tracking index (CTI) of terminal blocks shall be at least 200 when tested per IEC 60112.

1.12.10 Terminal blocks shall be mounted on grounded DIN rails at an easily accessible position approximately 30 cm above the base and shall be equipped with barriers, and color-coded terminal strips. The AC, DC and CT and PT circuits shall be physically segregated in groups. The terminal blocks for CT secondary wiring shall be of shorting type and clearly marked to indicate the CT's phase and ratio in use. CT's shorting type terminal blocks shall provide a ground connection when CT shorting is applied. All PT circuits shall be provided with sliding link type terminal blocks.

1.12.11 All AC circuit terminals and DC power terminals shall be fitted with non-inflammable, transparent plastic covers to prevent accidental contact with live parts. Each incoming and outgoing conductor shall be connected to an individual terminal through size 1 hooked crimps or ring type terminals.

1.12.12 At least 20% spare terminals of each type shall be provided on each block for terminating spare conductors and for future changes. All terminal connections shall be made with pre-insulated crimp lug connectors. Terminals shall be made of phosphor bronze or brass.

1.12.13 Terminal blocks shall be provided for conductors requiring connection to circuits external to the specified equipment. The clear space between two rows of terminal blocks shall be 50mm.

1.12.14 All spare auxiliary switches shall be wired and terminated on the terminal blocks in the control cabinet.

1.13 Grounding

1.13.1 The GIS enclosures shall be grounded.

1.13.2 Necessary terminal pads and connectors suitable for accommodating 2x300mm^2 stranded copper conductors shall be provided at a number of points on the GIS enclosure/support structure to effectively connect switchgear enclosure to the substation ground mat/mesh.

1.13.3 The grounding connections must meet the requirements of IEEE 80 and IEEE 367. Grounding for mitigating over voltages during disconnect switch operation shall be provided considering the transient increase of potential of the GIS enclosure relative to the substation ground. If necessary, isolating means shall be provided to avoid current loops via other substation equipment, such as transformers or separate switchgears at HV and EHV levels. All support structures of GIS shall have grounding provision.

1.13.4 For the interconnection of enclosures, frames, etc., fastening (e.g. bolting or welding) is acceptable for providing electrical continuity. The continuity of the grounding circuits shall be ensured taking into account the thermal and electrical stresses caused by the current they may have to carry.

1.13.5 All auxiliary equipment such as operating mechanism boxes, terminal boxes and control cabinet, which are not an integral part of the switchgear assembly, shall be provided with suitable connectors for independent grounding.

1.13.6 Shorting straps or suitable electrical conducting parts shall be provided at all flange joints if flange-to-flange continuous connections of enclosures are not provided, to allow safe passage to fault-currents without exceeding the permissible limits of enclosure temperature and to reduce electromagnetic interference. 90° bends in grounding bars shall be avoided.

1.13.7 GIS manufacturer shall recommend the energy absorption and voltage rating of the non-linear resistance/surge arresters to be provided symmetrically across the insulating joints of the enclosures, flanges at cable termination with shield break and SF_6-to-Oil transformer termination to bypass very fast transients generated in GIS per IEC 60859 or IEEE 1300. Calculation for non-linear resistance/surge arresters sizing shall be furnished per guidelines specified in IEEE C37.122.1 for SEC review. Metallic base of SF_6-to-Air Overhead Line Termination shall be properly grounded to mitigate the effect of very fast transients generated in GIS.

1.14 Nameplate

1.14.1 A non corrodible metal name plate shall be attached to each Circuit Breaker in a position which shall be clearly visible to a person standing on a ground. The name plate should list the data specified in Clause 5.9 of IEC Publication 60056.

Each main component of the switchgear shall be provided with a nameplate written in English per applicable IEC or ANSI/IEEE standards as listed under clause 3.0 with the following additional information.

a. Rated Voltage " _____ kV

b. Manufacturer's name or Trademark

c. Year of Manufacture

d. Type Designation/Serial Number

e. Purchase Order Number/ Contract Number/Job Order Number

f. Rated SF6 gas pressure for operation at 20°C

g. Minimum SF6 gas density for insulation

h. Design pressure for enclosure

1.14.2 The nameplate of switchgear assembly shall have all the above details along with the weight of the transformer bay, line bay, feeder bay and complete switchgear. The operating mechanisms and driving motor shall also bear it's own nameplate. The current transformer nameplate shall contain the information listed for all taps.

1.14.3 The name plate material shall be stainless steel or non-corrodible material but shall not include plastic, and shall be fastened to the equipment by stainless steel screws or rivets. All markings shall be engraved or etched in black and shall be non-fading.

1.15 Bus bar Assemblies

1.15.1 The bus bar system shall:

a. include plug-in conductor joints and all interconnections, designed to withstand thermal expansions and carry rated normal current and withstand short circuit currents as specified in data schedule.

b. be sectionalized for each bay and contained in individual SF6 gas tight

bus compartments to prevent contamination of the gas of the whole bus bar due to fault in one bay zone and refill lesser quantity of SF6 gas. For long length of bus ducts, individual gas tight bus compartment shall be not be more than 18m length.

c. Be provided with insulated supports within the enclosure.

1.15.2 The bus support insulators shall be:

a. Of adequate strength to withstand electrical and mechanical stresses that may be encountered in service.

b. Free from all voids and irregular surfaces.

1.15.3 Non-barrier insulators shall permit the gas pressure to equalize between the compartments. Conductive particle traps shall be placed at the support insulators, whenever required. Insulators shall be non-tracking type.

1.15.4 Field welding of the conductor inside GIS component is not acceptable.

1.15.5 Suitable bus elbows, tees, bellows shall be provided as per the manufacturer's standard and recommendations depending on the mechanical stress and vibration expected. The bus ducts shall be provided with shipping caps and pressurized with positive pressure by dry air or nitrogen for shipment.

1.15.6 The phases in all new GIS substations shall be designated as R (Red), Y (Yellow) and B (Blue) throughout the substation when viewed from East to West, from North to South and from Top to Bottom. For reinforced substations the three phases shall be designated as per the existing system.

1.16 Circuit Breakers

1.16.1 Circuit breakers shall:

a. Be of single-pressure, dead-tank design per IEC 62271-100 or ANSI C37.06.

b. Have modular design of the operating mechanism for quick replacement.

c. Have 3-phase auto-reclosing feature with annunciation for auto-reclosure fault and blocked conditions if specified in the data schedule.

1.16.2 The circuit breaker shall be designed for simultaneous three (3) pole operation. Circuit breakers requiring external devices in order to accomplish

their rated interrupting capabilities are not acceptable.

1.16.3 All rated parameters of the circuit breaker including the breaking time shall be complied with at the minimum permissible gas density.

1.16.4 The total interrupting time at all currents less than the rated short circuit interrupting current shall not exceed the rated maximum interrupting time. Re-strikes shall not occur during any type of load switching and fault interruption.

1.16.5 The first pole-to-clear factor shall be 1.5. The circuit breaker shall have a rated duty cycle 0-0.3 sec-CO-3 min.-CO.

1.16.6 The control power supply to all trip and closing coil circuits shall be provided with isolating switch. One auxiliary contact of this switch shall be wired to alarm when the switch is in open position. Both positive and negative poles of the close coil shall be switched.

1.16.7 The operating mechanism shall be motor-wound spring-operated, Single pole circuit breaker employing single-pole operating mechanism shall be electrically coupled for synchronous three-pole operation. The circuit breaker mechanism shall be mechanically trip free. Anti-pumping feature shall also be provided.

1.16.8 Each breaker operating mechanism shall be equipped with a non-resettable mechanically actuated five-digit operation counter to indicate the number of opening operations performed by the circuit breaker. Each housing shall have a removable conduit plate or sufficient conduit knockouts for bringing in wiring conduit.

1.16.9 Motor-wound spring-operated mechanism shall employ a maintenance-free motor, rated 220VDC for spring charging. The energy storage of a motor-wound spring-operated circuit breaker shall be sufficient for an open-close open operation without replenishing the stored energy. Means shall be provided to prevent overcharging of spring. Mechanical indication of spring(s) for both "charged" and "discharged" states shall be provided. Provision shall also be made for remote indication of "spring charge fail" condition. Provision for manual spring charging shall be provided, which shall automatically cut-off the power supply to the motor during manual charging.

1.16.10 The circuit breaker shall be supplied with two (2) electrically independent DC shunt trip coils and one closing coil per operating mechanism. Each trip coil shall operate satisfactorily between 123V DC and 246V DC for its rated voltage of 220V DC. The closing coil shall operate satisfactorily between 158V DC and 246V DC & for its rated voltage of 220V DC.

1.16.11 Single pole type circuit breakers with individual operating mechanism shall be provided with pole-discrepancy protection with time delay for tripping both trip coils (1st stage) and adjacent breakers (2nd stage).

1.16.12 The operating mechanism shall be provided with anti-condensation heater and located in an accessible position of the circuit breaker. All gauges, counters and position indicators shall be readable by the operator standing on the substation floor near the equipment.

1.16.13 Motors in the operating mechanism shall be protected/controlled by suitable miniature circuit breakers or fused knife switch.

1.16.14 The circuit breaker shall have mechanical position indicators for the main contacts. The mechanical position indicator shall indicate the open and closed positions of the circuit breaker. The markings shall be in white letters as "Open" or "0" on a green background and "Closed" or "C" on a red background.

1.17 Interlocking

The following interlocks shall be provided for reasons of safety and convenience of operation. The electrical interlocking shall be effective under both local and remote operations.

1.17.1 Manual operation of the disconnect and grounding switches shall only be possible under electrical interlock release conditions as specified in project scope of work.

1.17.2 Electrical interlock schemes shall be fail-safe to prevent loss of interlock function upon loss of control voltage.

1.17.3 Mechanical and Electrical interlock between disconnect and grounding switch operation shall be provided.

1.17.4 Electrical interlock between line PT secondary voltage and respective line grounding switch operation shall be provided through under voltage relay contacts.

1.17.5 Feeder grounding switch shall be interlocked with corresponding circuit breaker and disconnect switch.

1.18 SF_6-TO-AIR BUSHINGS WITH GIL

1.18.1 For connecting 500kV lines and transformer with the GIS, SF_6-to-Air outdoor bushings, mounted on suitable steel structures shall be installed. The bushings shall be polymer and shall generally conform to IEC 60137 or IEEE C 37.09.

1.18.2 The SF_6-to-Air terminations shall include all necessary materials such as SF6 interface bus duct, gas monitoring devices and removable links to ensure complete termination.

1.18.3 The SF_6-to-Air termination shall be provided with bursting/rupture disc. To obtain the necessary air clearance at the outdoor terminals, the bushings shall be splayed using suitable shaped enclosure section.3.16 Control Cabinet

1.18.4 Each bay of the switchgear shall be provided with a control cabinet for the local control and monitoring of the respective bay components and shall be preferably placed in front or adjacent to their respective GIS bays.

1.18.5 The control cabinet shall be freestanding, made of sheet steel and provided with lockable-hinged door and door operated lights. The cabinet shall be self-contained, fully assembled and factory wired for the required application and designed per IEC60439 or ANSI/IEEE C37.123. The control cabinets shall be painted per 01-TMSS-01.

1.18.6 The cabinet shall accommodate auxiliary relays, contactors, all necessary control switches including the local/off/ remote lockable selector switch, interlocks, devices, "Close" and "Open" push buttons (momentary contact type), all position indicators for circuit breakers, disconnect switches and grounding switches, alarms, instruments AC, DC supply terminals, terminal blocks or multiple plugs for electrical connections to components, auxiliary power supplies etc. of the assigned bay so as to facilitate full and independent control and monitoring of the switchgear locally. All electronic components inside the bay control cabinet shall be designed to work satisfactorily for the specified ambient temperature. At least 10% spare contacts (NO & NC) shall be provided with each auxiliary relay.

1.18.7 Alarm/annunciators shall be window type per IEC 60255 (applicable parts) or ANSI/IEEE C37.1 with a minimum of 10% spare windows. Annunciators shall be provided for monitoring the gas density of each gas compartment, high gas pressure before operation of rupture disc/pressure relief device, hydraulic/pneumatic operating mechanism failure and its pump/compressor excessive running, operation of breaker pole discrepancy and trip circuit failures and operating mechanism/control circuit failure.

1.18.8 Alarm/annunciator equipments shall be microprocessor based with high noise

immunity and reliability and of modular design with LED type indicators for visual display. The alarm/annunciator system shall be designed for continuous operation of all alarms independently and simultaneously. Annunciator system shall be provided with push buttons for "Silence", "Acknowledge", "Reset" and "Test or Simulation".

1.18.9 Suitable provisions (wired terminals) shall be made to enable all alarm conditions (per SCADA Point List) to be connected to remote signaling system (SOE and SCADA).

1.18.10 Except for CT and PT secondary circuits, all LV connections between HV component and local control cabinet may have multipoint, coded plug connectors or conventional type terminal block at each end. Provision for mounting necessary test switches for CT and PT and other circuits shall also be provided.

1.18.11 A mimic diagram shall be provided on the front of the cabinet showing:

Necessary control switches and local remote changeover switch (lockable), for operation of circuit breakers, motorized disconnect switches and (applicable) grounding switches.

a. Position indicators (semaphores) for all circuit breakers, disconnect and grounding switches in the assigned bay.

b. Key-switch for overriding interlocks between disconnects and grounding switches associated with circuit breakers.

c. SF6 gas partitions.

1.18.12 The cabinet shall be provided with thermostatically controlled anti-condensation space heater along with the 220Vac interior lighting with door switch, safety shrouds, and one 15A, 22OVac tandem slot type receptacle. One ammeter each for each transformer bay, bus section bay and feeder bay, and one voltmeter with selector switch for each bus section and feeder bay and key-switch for overriding interlocks between disconnects and grounding switches associated with circuit breakers during maintenance shall also be provided in the control cabinet.

1.18.13 All control power circuits shall be protected by miniature circuit breakers (MCBs)/fuses, in each cabinet. Other circuits supplying loads, such as heaters, receptacles, or lights, shall have separate overload and short-circuit protection.

1.18.14 Unless otherwise specified, the DC supply voltage shall be 220V for all control and protection and annunciator circuits. 220Vac backup supply shall be provided for the annunciator system.

1.18.15 A copper ground bus bar of suitable dimensions shall be provided at the bottom of the cabinet for grounding. The hinged door of the panel(s) shall be grounded by a flexible grounding connection.

1.18.16 K-Electric approved schematic diagram of the part of the control system, local to the control cabinet, identifying various components within the cabinet and the respective switchgear bay and referring to the appropriate drawings and instruction manual shall be affixed inside of the cabinet access door. The schematic diagram shall be protected with a durable, non-fading material, suitable for the specified climatic conditions.

1.19 Tests

STL/ILAC Accredited internationally recognized laboratory shall certify the type test reports.

General:

The circuit breakers shall be subjected to tests in the shop and at site in the presence of the inspectors nominated by Employer for conformity to the requirements of the Specifications.

Six (6) certified copies of the tests made, and of the results thereof after the tests are made, shall be furnished by the Contractor to the Engineer for approval. The results of these tests shall be in such form as to provide means of determining compliance with the applicable Specifications for the material tested. If any item of the plant is of a new design or if essential parts have been redesigned, additional test reports to verify this data shall be submitted for Engineer approval.

Tests required herein shall be carried out in accordance with the latest issue of IEC Publication of IEC-60056 and IEC 60694.

All test results shall be provided for review and approval by K-Electric.

1.19.1 Type (Design) Tests

All type (design) tests prescribed in the relevant IEC or equivalent ANSI/IEEE standards, as listed under clause 3.0, shall be performed on a complete functional assembly of one representative bay having same design, arrangement and ratings as of those to be supplied or on the first unit of every new design, rating or size to be supplied to K-Electric. The type test shall be conducted at an internationally recognized Independent Testing Laboratory and in the presence of representatives of K-Electric approved Inspection Agency. Short line fault interruption capability test shall be applicable for all circuit breakers in GIS.

1.19.2 Low leakage flux tests shall be performed per IEC 60044-6 at all taps for class "TPS" CTs. This test shall be performed when the value of factor of construction Fc < 1.1.

1.19.3 When requested, chopped (at 2µs) lightning impulse (1.2/50µs, 1.29 times BIL) tests and chopped (at 3µs) lightning impulse (1.2/50µs, 1.15 times BIL) tests shall be performed on high voltage circuit breaker for reactor switching per IEC 62271-110.

1.19.4 Certified test reports of type (design) tests performed on a complete functional assembly of one representative bay having same design, arrangement and ratings as of those supplied earlier and acceptable to K-Electric, may be submitted for review and acceptance in lieu of the required design (type) tests above.

1.19.5 Six copies of the test reports shall be submitted for Engineer review and approval.

The required type tests are as follows:

(1) Dielectric tests.

(2) Proof tests for enclosures

(3) Tests under conditions of arcing due to an internal fault.

(4) Thermal stability tests.

(5) Temperature rise tests.

(6) Measurement of the resistance of the main circuit.

(7) Short-time with stand current and peak withstand current tests.

(8) Mechanical and environmental tests.

(9) Short circuit making and breaking tests.

(10) Short-line fault test.

(11) Out-of-phase making and breaking tests.

(12) Capacitive current switching tests.

(13) Magnetizing and small inductive current switching tests.

(14) SF6, Gas Monitoring, Insulation Level and Leakage Tests.

(15) **Contacts Opening/Closing Time:** The circuit breaker shall be tested to demonstrate that all main contacts in different poles open or close within 6.6 milli seconds time.

1.20 Routine (Production) Tests

Routine tests shall be carried out on all circuit breakers and supports furnished under this Contract at the factory after final assembly, in accordance with the latest issue of IEC Publication 60056. Six copies of the certified test reports shall be submitted for Engineer review and approval in accordance with these Bid Documents. No equipment shall be shipped until the required routine tests have been approved by the Engineer

(1) Power frequency voltage with stand dry tests on the main circuit.

(2) Voltage withstand tests on control and auxiliary circuits.

(3) Partial discharge measurement

(4) Measurement of the resistance of the main circuit.

(5) Mechanical operating tests.

(6) Design and visuals checks.

(7) Coil check test.

(8) Tightness test.

(9) SF6, Gas Monitoring, Insulation Level and Leakage Tests.

1.20.1 All routine (production) tests prescribed in the relevant IEC or equivalent ANSI/IEEE Standards as listed under clause 3.0, shall be performed on all switchgear assemblies and on individual switchgear components.

1.20.2 Partial discharge measurement shall be performed on all PTs manufactured per IEEE standard.

1.20.3 The following additional tests shall be performed in accordance with IEC 60044-1/IEC 60044-6 or equivalent at each tap for all CTs:

a. Turns ratio error.

b. CT secondary resistance (Rct).

c. Excitation Characteristics.

1.20.4 The following additional test shall be performed for CTs manufactured per IEEE/IEC:

a. Determination of knee point voltage (V_K) for class "C" or "K" CTs manufactured per IEEE C57.13.

b. Determination of excitation limiting secondary voltage (Ual) for class

"TPS" CTs manufactured per IEC 60044-6.

1.21 Commissioning Tests

The commissioning tests shall be performed on GIS as specified.

1.22 Special Tools

All special tools required for the purpose of installation, maintenance, overhauling and testing of GIS, operating mechanisms.

1.23 CONSTRUCTION

8.23.1 **General:**

Main assemblies shall be of modular design having same opening distance between the fixed and moving contacts. Any interrupter shall be removable without affecting the other interrupter or support column insulator.

The circuit breaker shall be autonomous in gas supply, and no permanent external gas accumulators or piping shall be required. For refilling purposes, portable SF6 gas bottles shall be furnished. Refilling shall be possible while circuit breaker is in service.

The construction of the circuit breaker and the associated equipment shall ensure safety of personnel. The isolation from live parts shall be by elevation. All moving parts shall be suitably covered.

1.23.2 Finish:

On all outside surfaces of metal parts, one coat of metal primer shall be applied. During application, special attention shall be given to welded seams. All exposed nuts and bolts shall be treated to prevent corrosion. The Color of the GIS shall be RAL7035

1.24 PROVISIONS FOR SCADA AND REMOTE-CONTROL FUNCTIONS

Provisions shall be made for remote open' and 'close' operations, position indications and failure alarm (at remote stations) as specified in Section 15 of these Technical Provisions.

Identified terminals in the control boards shall be wired to auxiliary contacts of the circuit breakers. The auxiliary contacts shall comprise separate parts for NO and NC potential free contacts for open and close positions respectively.

1.25 LOCAL CONTROL CUBICLES AND COMPONENTS

1.25.1 General:

Local control cubicles of all the circuit breakers shall be vermin proof and weather proof, of protection Class IP54. The master control housing shall contain all breaker indicating devices, mcbs for AC and DC circuits, closing and tripping controls, and alarm relays for all the necessary mechanical and electrical apparatus and accessories required. All mcbs shall be provided with auxiliary contacts and sensitive earth fault protection for personnel safety. Separate mcbs shall be provided for heating and lighting circuits.

There shall be a neoprene gasket between the door and frame to prevent the ingress of moisture. Each of the cubicles shall be mounted so as to be accessible from ground level. Structural backing shall be provided, where required, in such a manner that the complete assembly shall be rigid, self-supporting and free of vibration, twist and weave.

1.25.2 Cubicle Interior:

No equipment shall be mounted less than 300 mm above the floor of the cubicle or 150 mm from the roof. Any unused areas of panels shall be kept free of wiring to permit the installation of possible future components.

1.25.3 Doors and Latches:

Each cubicle shall be equipped with a hinged door with hinges on the left.

The door shall have its edge bent inwards for rigidity. There shall be a three-point latch and activating handle. The handle and door shall have matching projections with a 12.5 mm diameter hole suitable for locking the cubicle door with a padlock.

1.25.4 Lighting, Outlets and Telephone Jacks:

Interior lighting operating from a door switch shall be provided within each cubicle assembly. A 240 V, 5A single phase three pin convenience outlet alongwith its mcb to fit standard prong plugs shall be installed inside each cubicle assembly.

A telephone jack shall be provided in each cubicle assembly. A hook for supporting head set shall be provided conveniently close to the jack. Telephone wiring upto control desks, relay room and PLC room in the control building shall be provided for work during erection and maintenance.

1.25.5 Ground Bus:

A copper ground bus bar shall be provided with tapped holes and screws and shall be connected to the shields or associated earth continuity conductors of all incoming cables.

1.25.6 Control Circuit:

220V, DC miniature circuit breakers shall be provided for protecting DC control circuits.

1.25.7 Terminal blocks and Terminals:

Terminal blocks for control wiring shall be molded disconnecting type with marking strips and covers. White marking strips shall be provided for circuit designation. Each connected terminal of each block shall have the circuit designation. Terminal studs and wires shall be numbered or otherwise marked in accordance with the applicable schematic and wiring diagrams with permanent contrasting marking fluid.

Terminal blocks shall be arranged with sufficient room for easy connection of incoming cables. Parallel rows of terminal blocks shall be spaced at least 150 mm apart. At least 20% spare terminals shall be provided in each block or group of blocks.

Blocks shall be mounted in vertical columns along the sides of cubicles or on vertical panels specially provided for terminal blocks.

1.25.8 Component Wiring:

Wiring between terminals of various devices shall be point to point (no splicing or 'T' connection shall be allowed). All internal wiring shall be neatly truncated in wiring troughs.

All groups of bundled conductors to hinged doors and panels shall use extra-flexible wire arranged so that a twisting, rather than a bending motion is imparted to the moving conductor bundle.

All wires shall be identified at both ends according to the interconnection diagrams.

1.25.9 Heaters:

Space heaters of sufficient capacity alongwith thermostat, humidistat, control switches and circuit breakers shall be supplied for each control cabinet to reduce condensation which may occur. Auto-Off-Manual' selector switch shall be provided for selecting the operating mode of the haters.

1.25.10 Schematic Diagram:

A schematic diagram of the control circuit block of the circuit breaker shall be provided.

1.26 MOTORS

All motors shall conform to IEC standards for motors and as specified herein:

Fractional horsepower motors shall be rated for 230 V, single phase, 50 Hz supply. All other and reversing motors shall be rated for 400 V, three phase, 50 Hz.

The motors shall be squirrel-cage induction type, direct on line starting, normal starting torque, low starting current.

The motor shall be single speed having a continuous service factor of 1.0.

1.27 STRUCTURES

The structural steel supports for the circuit breakers as well as all necessary related steel materials shall be designed in accordance with design parameters and instructions given in Section 5 of these Provisions as applicable to GIS switchgears.

1.28 MATERIAL AND WORKMANSHIP

The material and workmanship throughout shall be of the best quality in accordance with accepted modern practices. The design shall be such that installation, replacements and general maintenance may be undertaken with a minimum of time and expense. Each complete unit shall be designed for continuous operation at full-rated capacity and liberal factors of safety shall be used throughout the design. All screw threads and bolt sizes shall comply with ISO Standards for metric threads.

1.29 SHOP CLEANING AND PAINTING

The switchgear shall be treated and protected to withstand at least five years of operation under the environmental conditions prevailing at site without sustaining significant corrosion or attacks from fungus or rodents, provided the surfaces remain mechanically undamaged.

All interior and exterior surfaces of tanks, enclosures, and other metal parts which are not galvanized shall be thoroughly cleaned by degreasing and abrasive blasting, or other equivalent means to remove all grease, scale, corrosion, and foreign substances, subject to the approval of the Engineer. All interiors and exteriors except tanks which shall receive the Manufacturer's standard treatment shall be given at least one priming coat and one finish coat of light coloured paint or enamel. Interiors of operating compartments shall have a finish coat of gloss white. All exteriors shall be given not less than 3 coats of paint consisting of primer and finish enamel. The finish coat shall have high grey colour. The total dry film thickness of the 3 or more coats of paint shall not be less than 0.09mm, of which not less than 50% shall be finish enamel.

All machine-finished or bright surfaces shall be thoroughly cleaned, coated with a suitable, easily removable, corrosion resisting compound and wrapped or otherwise protected from damage during shipment. Four liters of finish paint shall be furnished for re-finishing damaged

surfaces after erection.

1.30 DRAWINGS AND DESCRIPTIVE DATA

1.30.1 **Tender Drawings:**

The following drawings, information and descriptive data shall be supplied with the bid:

(1) The requisite information required to be supplied with the Bid in accordance with Sub-clause 9.102 of IEC Publication 60056 and shall be supplied in the manner and form given therein.

(2) Outline drawings, photographs, descriptive sheets and sketches to describe clearly the construction and operation of the circuit breaker.

(3) The details of the minor and the general maintenance requirements for servicing and replacement of the contacts, and the requirements of maintenance on the number of switching operations at:

(a) Full short circuit capacity (100 percent).

(b) Half short circuit capacity (50 percent).

(c) Quarter short circuit capacity (25 percent).

(4) Full description of any device incorporated in a circuit breaker to limit or control the rate of rise of re-striking voltage across the circuit breaker contacts.

(5) The details of the operating mechanism', literature and catalogue data showing full details of the opening and closing sequences of the mechanism under all conditions.

(6) Type test reports.

(7) Instruction manual.

(8) Experience records for the offered type of breakers.

1.30.2 **Approval of Drawings:**

(1) Approval Drawings shall show the detailed physical arrangements of the breaker, high voltage connections, wiring and schematic diagrams of the control scheme.

(2) Also provided shall be the transport, storage, installation, erection, maintenance and operation instruction books. These instructions to be written in accordance with IEC Publications 60056 and 60694.

(3) Impact loading of circuit breaker during the opening and closing operations.

(4) Test reports.

(5) Any other information that the Engineer may require.