

Section - 2

CUSTOMER'S EQUIPMENT SPECIFICATION

420 kV SF6 GAS INSULATED SWITCHGEAR

7.1 SCOPE

7.1.1 The scope of work under this section covers the 420 kV SF6 gas insulated switchgear GIS for indoor/outdoor installation, consisting of circuit breakers, current transformers, potential transformers, disconnect switches, ground switches, CGI bus ducts, lightning arrestors, transition bus section between GIS and SF6 bushings, supporting steel structures as outlined under schedule of requirement and all other equipment not explicitly mentioned herein, as per the specifications hereunder, each complete with all auxiliary, accessories, spare parts and warranting a trouble free safe operation of the installation.

The equipment shall be suitable for climatic conditions as detailed in Section-3 of this document.

7.1.2 The supplier, shall furnish all operating mechanism, applications, material, supervisory staff and any other works incidental to and connected with the above services from delivery till handing over the equipment after successful commissioning not herein specifically mentioned or included, but which may be found necessary to complete or test any portion of the apparatus or equipment mentioned in these specifications, at no extra cost to the purchaser.

7.1.3 The scope of supply must include all spares as mentioned in schedule of requirement. These spares are considered to be sufficient for normal operation of equipment for 5 years. If however, bidder feels that certain additional spares are required or certain spares could be deleted, he may give his recommendation separately in Schedule and state the prices involved. Spares shall be of the same material, dimensions, workmanship and finish as that of original.

7.1.4 The Supplier shall bring all erection tools and tackles, testing equipment including H.V. test kit, and other testing instrument required during erection, testing and commissioning of entire equipment. Cost of arranging the same is deemed to be included in the cost of on site erection, testing and commissioning.

7.1.5 End covers of enclosures, if any, supplied alongwith each individual shipping unit of equipment for protection during transit shall be taken back by the Supplier at his cost.

7.1.6 Empty steel bottles/cylinders of SF6 after first filling of equipment shall be taken back by the Supplier at his cost. The quantity of SF6 supplied as spare shall however be supplied in non-returnable steel bottles/cylinders.

7.1.7 The scope of work shall also include the training of engineers and erection, testing & commissioning of the equipment specified herein.

- 7.1.8
- i) Continuous on-line monitoring and diagnostic systems to monitor partial discharge, internal arcing, gas density, gas pressure, leakage, moisture (offline) etc., operating parameters such as current, voltage, temperature etc. complete with sensors, control/processor units, wiring/cabling in all respect and integration of the systems with plant SCADA system.
 - ii) Coordination and provision of necessary contacts and/or ports for integration with plant SCADA system.

7.2 SYSTEM DETAILS

- 7.2.1 The SF6 gas insulated switchgear shall be suitable for indoor operation with **3 phase, 50 Hz, 400 kV nominal, 420 kV highest system voltage, 800 A, 50 kA short circuit rating, equipment comprising of 7 bays** (6 bays incoming from three phase 6 Nos., 84 MVA transformers, and one bus coupler bay of capacity 4000A located at El. 889 m in the Power House Building and on a floor above 420 kV transformers and designated as GIS. **The rating of the bus bars will be 4000 A.** Double bus bar system shall comprise of circuit breakers, current transformers, potential transformers, disconnect switches, safety ground switches, high speed make proof grounding switches, lightning arrestors, transition bus section between Gas Insulated Switch Gear and Oil-SF6 bushing of the main transformers etc.

GIS switchgear shall also comprise of circuit breakers, current transformers, potential transformers, disconnect switches, ground switches, high speed make proof grounding switches, transition bus, SF6-Air bushings. **There will be 4 outgoing bays as follows:-**

- a) **2 bays for inter-connection from NJHEP, Jhakri.**
- b) **2 bays for inter-connection to Nalagarh.**

The rating of generating bay and feeder bays shall be 800 A and 2000A respectively, 50 kA short circuit rating. The rating of bus bars shall be 4000 A.

7.3 STANDARDS/DRAWINGS

- 7.3.1 The material to be furnished by the supplier including all accessories and equipment obtained by him from others, which are specified by reference shall preferably be as per IEC standards wherever existing and shall be in compliance with the latest editions or revisions thereof. The supplier shall supply copies of various standards contemplated to be followed, in the tender, free of cost. Though a few preferred IEC standards are mentioned below, the list is not exhaustive and may be improved:-

IEC 694	Common clauses for HV switchgear
IEC 517	HV metal-enclosed switchgear above 72.5 kV
IEC 56	Parts 1 to 6-AC High voltage circuit breakers
IEC 129	AC disconnectors and earthing switches
IEC 267	Guide to testing of circuit breakers
IEC 185/186	Current and voltage transformers
IEC Rec.376	SF6 Gas
IEC Publ. Sec. 187, 192	earthquake 50A

IEC 99-1 IEC TC 37 WG 4(194) IEC 9.4 Surge arrestor
IEC 137 Outdoor bushing
IEC 270 Partial discharge measurement
IEC 506 Switching impulse test on HV insulators.
IEC 1128 – Alternating current disconnectors bus transfer current switching by disconnectors.
17 c (Sec) 121, 17 c (Central Office) IEC 1259 Requirement for switching of bus charging current by disconnectors.
IEC 1129 – AC earthing switches induced current switching.
IEC-68 Part III Seismic Test methods for equipment
IEC-1259 Requirement for switching of bus charging current by disconnectors.
IEC-1639 Direct connection between power transformers & SF6 GIS Current Transformers.
IS -3156 Voltage Transformers
IEC 480 – guide to the checking of SF6 taken for electrical equipments.
IEC 427 – Synthetic testing of high voltage A.C. circuit breaker.
IS 2705 – Protective Current Transformers for special (Part-IV) purpose application.
NSI/IEEE – Guide for safety in A.C. sub-station (Std. 80-1986) grounding.
IEC – 71 Insulation coordination.
IEC-859 Cable connections for gas insulated metal enclosed switchgear.

- 7.3.2 Bolts, nuts and screw threads shall conform to the relevant ISO standards. Unless otherwise specified, machine screw dimensions shall conform to these ISO standards. Plane washers, hexagonal head bolts and nuts not specifically mentioned, shall also conform to relevant ISO standards. Wherever necessary all threaded fastenings shall be provided with suitable locking devices.
- 7.3.3 The proposed switchgear may conform to any other authoritative standards which ensure an equal or better quality than the standards mentioned above. Each bidder must specifically indicate the standards to which the switchgear conforms and indicate all deviations (if any) from the preferred IEC codes that affect performance and rating.
- 7.3.4 Compliance of the switchgear manufacturer with the provisions of this specification does not relieve him of the responsibility of furnishing switchgear and accessories of proper design, electrically and mechanically suited to meet the operating guarantees at the specified service conditions.
- 7.3.5 If there are, in the opinion of the bidder, any conflicts between these codes and this specification these contradictions shall be brought to the attention of the buyer.
- 7.3.6 The following drawings shall form integral part of these specifications.

Sr.No.	Title	Drg. No.
1.	Single line diagram Relaying & Metering	TB-2-319-510-001
2.	Layout Plan at EL 889M.	RHEP – 538/06
3.	Layout Plan of EL 878M	SJVNL(ED)/ RHEP-540/06
4.	Schematic diagram for 48V DC System, DC Batteries, Battery Chargers & DC Distribution Boards	RHEP (E) – 513/05

5.	Schematic diagram for 220V DC System, DC Batteries, Battery Chargers & DC Distribution Boards	RHEP (E) – 514/05
6.	Key Plan of 420kV Pothead Yard	RHEP-545/06 (Sheet 1 of 3)
7.	Layout Plan of 420kV Pothead Yard	RHEP-545/06 (Sheet 2 of 3)
8.	Cross Section of Power House	SJVNL(ED)/RHEP -535/06
9.	Single Line Diagram for 22kV/415V supply for Power House, BFV, Surge Shaft, TRT Outfall	RHEP (E) – 516/05

7.4 RATINGS

7.4.1 The ratings and electrical characteristics of the complete GIS shall be as follows:-

(The ratings applicable to specific items of equipment are included in the applicable sections dealing with the equipment).

a)	Type of Switchgear	Three phase, metal enclosed SF6 gas insulated switchgear
b)	Location Indoor/outdoor	Indoor GIS
c)	Frequency	50 ± 3%
d)	Nominal voltage class kV	400
e)	Highest System voltage kV	420
f)	BIL (kV Peak)	
	i) to earth	1425
	ii) Across open switching device	1665
g)	Switching Surge (kV Peak)	1050
h)	One minute power frequency withstand voltage (kV rms)	
	i) to earth	520
	ii) Across open switching device	610
i)	System	Effectively grounded
j)	Continuous current (Amp)	
	i) In generating bays	800
	ii) In bus bars	4000
	a) Bus coupler bay	4000
	b) Feeder bays	2000

k)	Rated short circuit current at rated maximum voltage, for 1 Sec. not less than kA rms (Symmetrical)	50
l)	Rated making capacity (kA)	125 kA peak
m)	Prospective transient recovery voltage appearing across the circuit breaker terminals (kV)	As per IEC 56
n)	Radio interference voltage at 266 kV (rms)	Less than 2,500 micro volts
o)	Partial discharge level	10 or less pico-coulombs at $1.5 U_n/\sqrt{3}$
p)	Control voltage DC	220V +10%/-20%
q)	Auxiliary AC supply, 3 phase	415 V \pm 10%
r)	Maximum Gas leakage rate (%) of the respective volume, per year	1%
s)	Material of enclosure	Aluminium/ Aluminium Alloy
t)	Material of bus bar	Aluminium/ Aluminium Alloy.
u)	Insulation medium	SF6 Gas.

7.4.2 All current carrying components of the equipment specified shall be capable of continuous operation at the specified rated current without exceeding the maximum temperature rise specified in the relevant IEC standards.

7.4.3 Thermal calculations shall be based on the climatic conditions described in section-3 of this document.

7.5 GENERAL DESIGN AND SAFETY REQUIREMENTS

7.5.1 The GIS assembly shall consist of completely separate pressurized sections in order to de-pressurize one gas compartment for inspection, maintenance or, if necessary, repair while keeping the adjacent compartments in service. The number of compartments shall be as per Clause No. 7.5.15.

These compartments shall be designed to minimize the risk of damage to adjacent sections and protection of personnel in the event of a failure occurring within the equipment. Stainless steel partition diaphragms with suitable deflectors shall be provided to prevent uncontrolled bursting pressures developing within the enclosures.

- 7.5.2 Workmanship shall be of the highest quality and shall conform to the best modern practices for the manufacture of high technology machinery and electrical switchgear.
- 7.5.3 The switchgear, which shall be of modular design, shall have complete phase segregation. Each section shall be complete with high grade Epoxy resin, gastight seal-off insulators. These insulators shall be designed to have high structural strength and electrical dielectric properties and shall be shaped so as to provide uniform field distribution and to minimize the effects of particle deposition either from migration of foreign particles within the enclosures or from the by products of SF6 breakdown under arcing conditions.
- 7.5.4 The material and thickness of the enclosures shall be such as to withstand an internal flashover without a burn through for a period long enough (500 ms) to enable the backup relay protection to clear the fault.
- 7.5.5 Sufficient access openings shall be provided at the switchgear to ensure that each switchgear component can be inspected during installation or for future maintenance. Each section shall have easily removable connection pieces to allow for easy replacement of any component with the minimum of disturbance to the remainder of the equipment.
- 7.5.6 Materials used in the manufacture of the switchgear equipment shall be of the type, composition and have physical properties best suited to their particular purposes and in accordance with the latest engineering practices. All the conductors shall be fabricated of aluminium or aluminium alloy tubes of cross sectional area suitable to meet the normal and short circuit current rating requirements. The finish of the conductors shall be smooth so as to prevent any electrical discharge.
- The conductor ends shall be fitted with silver plated finger contacts or tulip contacts. The contacts shall allow the tubular conductors to expand or contract axially due to temperature variation without imposing any mechanical stress on supporting insulators.
- 7.5.7 Each pressure filled enclosure shall be designed and fabricated to comply with the requirements of the applicable pressure vessel codes of the country of origin. (Copies of the relevant codes shall be supplied to the purchaser free of cost) and based on the design temperature and design pressure as defined in IEC 517.
- 7.5.8 Manufacturer shall guarantee that the pressure loss within each individual gas-filled compartment will not be more than 1 percent per year.
- 7.5.9 Each gas filled compartment shall be equipped with static filters, density switches, filling valve and safety diaphragm. The filters shall be capable of absorbing any water vapour which may penetrate into the enclosures as well as the by products of SF6 during interruption. Each gas compartment shall be fitted with separate non-return valve connectors for evacuating and filling the gas and checking the gas pressure etc.
- 7.5.10 The switchgear line-up, when installed and operating under the ambient conditions shall perform satisfactorily and safely under all normal and fault conditions. Even repeated operations during the permissible servicing intervals

under full rated fault conditions shall not lead to diminished performance or significantly shortened useful life of the switchgear. Arc faults caused by external reasons shall be positively confined to the originating compartment and shall not spread to other parts of the switchgear. Routine replacement of insulating gas shall not be required in intervals of less than ten years.

7.5.11 Temperature rise of current carrying parts shall be limited to the values stipulated in IEC 694, under rated current and the climatic conditions as specified in clause 7.5 para 34 to 36.

7.5.12 Bracing shall be provided for all mechanical components against the effects of short circuit currents specified under clause 7.4. "Arc faults shall be positively confined to the originating compartment and shall not spread to the other part of the switchgear.

7.5.13 Thermal rating for all current carrying parts shall be a minimum of 1 sec. at 420 kV for the rated symmetrical short-circuit current. If the max. short-circuit time is to be extended, the I^2t value shall remain constant.

7.5.14 415V, 3 phase/240 V, Single phase, 50 Hz, A.C. & 220 V.D.C. auxiliary voltage supply for control alarm, operating mechanism and space heaters shall be available.

7.5.15 The switchgear shall be of freestanding, self-supporting, dead front design with all high-voltage equipment installed inside gas-insulated, metallic and earthed enclosures, suitably sub-divided into individual arc and gas-proof compartments, at least for:-

- a) Bus bars and bus bar isolators.
- b) Intermediate compartment
- c) Circuit breaker
- d) Line isolator
- e) Gas insulated bus duct section between generator transformer and GIS.
- f) Surge Arrestors.
- g) Current Transformers
- h) Voltage Transformers.

"Each phase/pole of GIS and CGI bus ducts shall be housed in the separate enclosures".

7.5.16 Arrangement of the individual switchgear bays shall be such as to achieve optimum space saving, neat and logical arrangement, and adequate accessibility to all external components.

7.5.17 GIS hall shall have tentative dimensions as under:-

- | | | | |
|----|--------|---|----------|
| a) | Length | - | 110 mts. |
| b) | Width | - | 8 mts. |
| c) | Height | - | 7.2 mts. |

While finalizing the layout plans of GIS, care should be taken to minimize the size of halls. The layout shall generally be shown on the drawings. Adjustment in layout shall be possible with purchaser's approval.

- 7.5.18 It is required that the three phases of each switchgear bay shall be arranged side by side. Segregated phase blocks of equipment in which one phase of each switch bay is mounted in a separate block are not acceptable. The arrangement of the equipment offered must provide adequate access for operation, testing and maintenance.
- 7.5.19 Each line of switchgear shall be suitable and prepared for future extension on either side and without any drilling, cutting or welding on the existing equipment. "To add equipment it shall not be necessary to move or dislocate the existing switchgear bays".
- 7.5.20 The switchgear shall be operated either from the front or from the side.
- 7.5.21 For routine inspections and possible repairs, all elements shall be accessible without removing support structures. The removal of individual enclosure parts, or entire equipment in any bay, shall be possible without disturbing the enclosures of neighboring bays.
- 7.5.22 It shall be impossible to unwillingly (i.e. without the use of tools or brute force) touch live parts of the switchgear or to perform operations that lead to arcing faults.
- 7.5.23 All interlocks that prevent potentially dangerous mal-operations, shall be constructed such that they cannot be defeated easily, i.e. the operator must use tools or brute force to over-ride them.
- 7.5.24 The actual position of circuit breakers, isolators and grounding switches must be positively displayed by mechanical indicators visible from the operating position.
- 7.5.25 Visible corona – In general the contours of energized metal parts of the GIS and any other accessory shall be such as to eliminate areas or points of high electrostatic flux concentrations. Surfaces shall be smooth with no projection or irregularities which may cause visible corona. No corona shall be visible in complete darkness when the equipment is subjected to test voltage specified.
- 7.5.26.1 The enclosure assembly shall consist of completely separate pressurized sections designed to minimize the risk of damage to adjacent sections and protection of personnel in the event of failure occurring within the equipment. The switchgear shall be designed so that induced voltage and temperature shall not exceed permissible limits. Stainless steel carbon impregnated or nickel plate rupture diaphragms with suitable deflectors shall be provided to prevent uncontrolled bursting pressure developing within the enclosures under worst operating conditions.
- 7.5.26.2 Workmanship shall be of the highest quality and shall conform to the best modern practices. Metal enclosures shall be fabricated from Aluminium/ Aluminium alloy, all joint surfaces shall be machined and all castings shall be spot faced for all bolts heads or nuts and washers. All screws, bolts, studs and nuts shall conform to metric system. The colour shade of paint applied on outer surface of the enclosures shall be as recommended by the Purchaser.
- 7.5.26.3 The breaker enclosure shall have provision for easy withdrawal of the interrupter assemblies. The procedure may not involve the removal or

- dislocation of enclosure parts of neighboring bay. The removed interrupter assembly must be easily and safely accessible for inspection and possible repairs.
- 7.5.26.4 The enclosures of the same phase shall be electrically interconnected. At proper points they shall be connected to the other phases thus entailing a return current almost equal to the current circulating in the conductors.
- 7.5.26.5 The enclosure shall be designed to practically eliminate the external electromagnetic field and thereby electro-dynamic stresses even under short circuit conditions.
- 7.5.26.6 Elbows, bends and T-Sections of interconnections shall include the insulator bearing the conductor at the change of direction to ensure that live parts remain perfectly centered and the electrical field is not increased at such points.
- 7.5.26.7 The supplier shall provide the following information for metallic particles loosely distributed within the GIS encapsulation:
- a) Calculation of critical field strength for specific particles of defined mass and geometry.
 - b) Methodology and equipment for electrical partial discharge (PD) detection and/or acoustic detection methods.
- 7.5.26.8 Each gas compartment shall be fitted with separate non-return valve connectors for evacuating & filling the gas, checking gas pressure etc.
- 7.5.27 The switchgear shall have provision for connection to the purchaser's grounding risers. The provision shall consist of grounding pads of unpainted steel, of suitable size. The tenderer shall furnish the details & drawings for ground mat requirement for GIS.
- 7.5.28 Ladders and walkways shall be provided wherever necessary for access to the equipment.
- 7.5.29 Wherever required, heaters shall be provided for equipment to ensure proper functioning of the switchgear at ambient temperatures, specified. The heaters shall be rated 240 V with thermostat, control switches and fuses, connected as a balanced 3-phases, 4-wire load. The heaters shall be so arranged and protected as to create no hazard to adjacent equipment from the heat produced.
- 7.5.30 Endoscope meter arrangement shall be provided to visually observe the contact position of circuit breaker, dis-connector and earth switches.
- 7.5.31 Provision shall be made for maintenance of equipment, so that a mechanic 1780 mm in height and 80 Kg in weight, shall be able to climb on the equipment.
- 7.5.32 Conductors and live parts shall be supported by solid moulded epoxy-resin insulators. These insulators shall be designed to have high structural strength and dielectric properties and shall be shaped so as to provide long creepage

distance, uniform field distribution and to minimize the effects of particles deposition either from migration of foreign particles within the enclosure or from the by-products of SF₆ breakdown under arcing condition.

Gas barrier and support insulators shall have the same basic design. Support insulators shall have holes for gas communication on both sides. Gas tight barriers shall be clearly marked on the outside of the enclosures.

Gas barrier insulators shall be provided so as to divide the GIS into separate compartments. They shall be suitably located in order to minimize disturbance in case of leakage or dismantling. They shall be designed to withstand 1.5 times full rated pressure on one side while vacuum is exerted on the other side. They shall also be designed to withstand any internal fault thereby keeping on internal arc inside the faulty compartment”.

7.5.33 Alarm circuit shall not respond to faults for momentary conditions. Following alarm circuits including those required elsewhere in the specification, shall be generally provided for indication of:-

7.5.33.1 **In the Gas Insulating System**

- a) Loss of gas density.
- b) Loss of heater power (failure of a.c. supply)
- c) Any other alarm necessary to indicate deterioration of the gas insulating system.

7.5.33.2 **In the Operating System**

- a) Low operating hydraulic pressure
- b) Loss of heater power. (failure of ac supply)
- c) Loss of operating power (failure of ac/dc supply)
- d) Loss of control.
- e) Pole-discrepancy

7.5.34 The equipment will be operated under the following ambient conditions. In the design of the equipment, these conditions shall be taken into account by the supplier as required.

- a. The ambient temperature at the project site and Average daily temperature inside the power house given in Section 3.
- b. The humidity will be up to 100 percent (indoors).
- c. For design purposes, the barometric pressure shall be calculated for elevation of 889 meters.

7.5.35 The completely assembled and installed equipment shall be able to withstand safely the dynamic forces induced in any part of the equipment by an “Equipment Design earthquake”. The earthquake forces shall be 0.2g in vertical direction and 0.4g in other two horizontal directions. For details refer to Section 3.

7.5.36 To prove the capability of the equipment to withstand the “Equipment design earthquake” the supplier shall model the equipment, mathematically as series of discrete mass points connected by members in such a manner that it will

represent the equipment completely installed and ready for service. The resulting system shall be dynamically analyzed using "Model Analysis". The calculations shall be supplied to the purchaser for his approval. Alternatively, the supplier may use other means, if agreed to in advance by the purchaser and shall supply all details of these tests alongwith the offer.

7.5.37 **Bellows or Compensating units**

Adequate provision shall be made to allow for the thermal expansion of the conductors and of differential thermal expansion between the conductors and the enclosures.

Metal bellows (preferably of stainless steel) of following types or suitable equivalent arrangement shall be provided wherever necessary:-

- i) Lateral mounting units: These shall be inserted, as required, between sections of bus bars, CGI bus duct connections, on transformer and CGI ducts termination. Provision of these shall enable sections of the switchgear to be removed and reinserted without interfering with adjacent parts. Lateral mounting shall be made possible by a sliding section of enclosure and tubular conductors.
- ii) Axial compensators: These shall be provided to accommodate changes in length of bus bars due to temperature variations.
- iii) Parallel compensators: These shall be provided to accommodate large linear expansions and angle tolerances.
- iv) Tolerance Compensators: These shall be provided for taking up manufacturing and assembly tolerances.
- v) Vibration compensators: These bellow compensators shall be provided for absorbing vibrations caused by transformers when connected to SF6 switchgear by Oil/SF6 bushings.

7.6 **CIRCUIT BREAKERS**

- 7.6.1 The three phase circuit breakers in each bay module shall be of the single pressure (Puffer) type. They shall be designed for installation in SF6 gas insulated metal clad switchgear and shall use SF6 gas for both insulation and arc quenching. Means shall be provided to ensure that all interrupters and secondary auxiliary switches open and close without loss of synchronism or of dielectric strength under all operating conditions including an open-close-open operation with zero external dead time delay. The interrupting duty shall be distributed uniformly between interrupters. The circuit breakers for lines shall be provided with independent and reliable operating mechanism for each pole whereas the circuit breakers for generating units and bus coupler shall be provided with common operating mechanism. Full details regarding electro hydraulic/spring operating mechanism and constructional & operational feature must be described in the bid. The detailed drawings to illustrate the operational features must be supplied.
- The operating mechanism employed shall be of proven design and shall be in service for a period of at least 5 years without failure/mal-operation at a number of installations supplied by the bidder.

7.6.2 Each circuit breaker shall be capable of withstanding without requiring change of any parts, at least 20 Nos. interruptions at rated short circuit current with associated rate of rise of recovery voltage. The bidder shall design the circuit breaker in accordance with the recommendation of IEC Publication 947.1 and 947.2. The service life of circuit breaker shall be at least 20,000 switching operation, at rated current/as per relevant IEC/IEEE standard. The supplier will also submit proof of short circuit rating with transient voltage severity.

7.6.3 OUT-OF-PHASE SWITCHING

The circuit breaker shall be capable of interrupting symmetrical short circuit current under out-of-phase switching conditions.

7.6.4 The circuit breakers shall meet the following Double Circuit transmission line characteristics for any type of fault or fault location, also for line charging and dropping when used on a 420kV effectively grounded system:

	Nalagarh	Jhakri
i) Line length (km)	127	22
ii) Line conductor	Triple Snow Bird	Triple Snow Bird
iii) Line parameters per unit per km as follows:		

Positive sequence:

$$Z_1 = 0.277 \angle 85.977^\circ$$

Zero Sequence

$$Z_0 = 1.124 \angle -14.16^\circ$$

The above values are indicative only and successful bidder will have to obtain confirmation from the purchaser about the modified correct values and design the equipment to suit corrected values.

7.6.5 Short line Faults : Circuit breaker supplied shall be capable of interrupting short line faults on overhead transmission line at amplitude factor of 1.5.

7.6.6 The circuit breakers shall be designed to withstand the high stresses imposed on them during fault clearing, load rejection, out of phase switching, re-energization of lines with trapped charges and perform make and break operations as per the stipulated duty cycles under item 7.6.40 of this clause satisfactorily. They shall also be required to break small inductive currents without causing excessive over-voltages, line charging currents without restrikes, handle evolving faults and meet the requirements; regarding partial discharge, radio interference and corona.

7.6.7 In rush and magnetizing current associated with large power transformers of 84 MVA, will have to be switched by the circuit breakers without restriking and without causing excessive switching surges. Occasionally, a power transformer operating under ferro-resonant conditions and having non-sinusoidal current and voltage wave-forms with higher than normal peak values will have to be switched. The supplier shall provide proof test data and comment on breaker for such applications.

7.6.8 **INSULATION CO-ORDINATION**

7.6.8.1 The insulation strength across the open contacts of the circuit breaker in respect of lightning impulse, switching surges and power frequency withstand voltages shall be as per IEC 694.

7.6.8.2 The circuit breaker and bus insulation shall be coordinated so that for impulse, switching surge and 50 Hz voltage high enough to cause flashover, shall take place in the bus rather than in the circuit breaker in either the open or closed position.

7.6.9 The circuit breaker shall have the required capabilities as defined in IEC-56.

7.6.10 Provision shall exist on the breaker for uprating the capacity at a later date.

7.6.11 **MECHANICAL REQUIREMENTS:**

Keeping in view the space limitations given in the layout, the circuit breakers shall be vertical/horizontal mounted depending on manufacturer's preferred layout for the double bus system and taking into account the worst service condition forces imposed by the earthquake withstand requirements stated in clause 7.5 para 35-36.

7.6.12 Each circuit breaker pole shall be equipped with a local enclosed type mechanical position indicator clearly visible from the breaker front, together with remote position indicator on the bay module control cabinet and remotely at the power house control room. The mechanical indicator wording and colouring shall be as follows :-

	<u>Sign</u>	<u>Background Colour</u>
Open position	Open	Green
Closed position	Close	Red

Each pole of the breaker shall be provided with operating counter to record the number of operations performed during service.

7.6.13 The circuit breakers shall be provided with pressure gauges and pressure relays for the operating mechanism.

7.6.14 The circuit breaker shall be supplied with thermostatically controlled tank heaters as required. Where the heater current rating exceeds one ampere, thermostatically controlled contactors shall be used.

7.6.15 The circuit breaker shall be provided with a rating plate which, in addition to the requirement of IEC, contains the voltage required to operate the tripping coil.

- 7.6.16 All circuit breakers except line circuit breakers shall be designed for 3-phase tripping and closing. Only line circuit breakers shall have single-phase and 3-phase auto-reclosing capabilities. The line breakers shall be capable of independent pole operation. Each phase shall be completely isolated from the other two phases.
- 7.6.17 The circuit breakers shall be trip-free and have anti-pumping and phase discrepancy protection. There shall be two trip coils per pole of the breakers.
- 7.6.18 All necessary interposing, interlocking control relays for circuit breaker tripping and closing shall be located in the control cabinets supplied by the supplier.
- 7.6.19 The circuit breaker shall be interlocked electrically with the associated isolators such that the isolator cannot be operated unless the associated circuit breaker is opened. The interlocking shall prevent any incorrect switching sequence and enable the breakers to be operated without risks, either from the local bay module control cabinet or from the power house control room. Actuation of the manual operating device shall also disable the electrical control circuits. Interlocks shall be provided to prevent from hunting and other dangerous or undesirable operations of the circuit breaker.
- 7.6.20 The circuit breakers shall also be key interlocked with the associated isolators and grounding switch such that the two keys are held captive when the circuit breaker is closed and released when the breaker is open. These keys shall then be used to enable the associated isolators to be opened manually. The keys in the isolators shall be held captive when the isolators are open.
- 7.6.21 The circuit breaker control system shall prevent closing of the circuit breaker when there is insufficient stored energy in the operating mechanism storage system, and insufficient SF6 gas density. It shall trip the breaker when the SF6 gas density drops below a minimum permissible level. The state of the breaker arc-quenching and insulating gas shall be monitored by a temperature-compensated pressure switch or density switch with two alarm levels. The first stage alarm shall be set well before any dangerous conditions is reached, the second stage shall initiate breaker operation. In addition, the actual gas pressure shall be shown on a local pressure indicator.
- 7.6.22 The circuit breaker shall be able to operate locally or from a remote point. Local operation shall be by means of an open/close control switch located in the bay module control cabinet. Remote control via a Remote/local control transfer switch will be from the power house control room. Protection trips will remain operational in either remote or local control mode. When in the maintenance mode, all remote trip or close control signals will be blocked. The breaker controls shall operate from the two independent 220 V DC systems with both the trip coils connected. A manually operated tripping device shall also be provided with each breaker which can be operated in an emergency or during maintenance. Mechanical indicators coupled to the movable contact system shall be provided to show the true position of the main breaker contacts. Operating counters shall be provided for each breaker pole or otherwise for each breaker. The four number circuit breakers provided on Jhakri and Nalagarh feeders shall be with pre-insertion resistors. System studies have recommended the value of pre-insertion resistor as 400 ohms for switching operation to limit over voltage.

- 7.6.23 Hydraulic controls are to be provided and such controls shall be interlocked to prevent the circuit breakers from being tripped under conditions which will not allow a complete and safe trip operation. A closed operation shall also be blocked unless a complete close-open-or trip-free operation can be safely carried out.
- 7.6.24 Control scheme for the circuit breakers shall be submitted by the supplier giving full details of operating mechanism and their advantages alongwith such drawings.
- 7.6.25 The circuit breaker shall be provided with duplicate electrical tripping facilities. Thus shall include but not be limited to the following:-
- a) Two electrically and magnetically separate identical trip coils. Simultaneous energizing of both coils shall not affect the breaker opening time. Non-polarised coils shall be preferred.
 - b) Two electrically independent and identical sets of wiring, terminals and protective equipment for connection to two independent control and/or tripping power sources.
- 7.6.26 The above noted requirement refers only to duplicate electrical tripping facilities and should not be interpreted as requiring the provision of any mechanical or hydraulic components in duplicate form.
- 7.6.27 The circuit breaker shall be provided with red and green local LED type indicating lamps which shall be connected through one normally open and one normally closed circuit auxiliary switch of each pole. The circuit breaker shall further be provided with amber lamp to indicate healthy trip conditions.
- 7.6.28 All necessary relays, switches and devices shall be provided to allow for local operation. A two-pole single throw switch shall be connected to isolate the closing devices and primary tripping coils from their potential supply and a further two-pole single throw switch shall be similarly connected to isolate the standby tripping coils. The control supply shall have provision of HRC fuses of appropriate capacities for overload protection.
- 7.6.29 The control devices shall operate within the following voltage ranges:-
- a) Breaker closing control 85% to 110% of 220 V DC
 - b) Breaker tripping control 70% to 110% of 220 V DC
 - c) A.C. Control devices 85% to 110% of 230 V, 50 Hz AC
- 7.6.30 All DC coils (trip, close, auxiliary, etc.) shall be equipped with surge suppression devices such as diodes across the coils to provide a discharge path for transient voltage. The provision of such devices shall neither extend the drop out time of coil nor shall interfere with normal operation of the circuit breaker.
- 7.6.31 Circuit breaker closing coil operated by minimum pressure interlocks must be continuously rated to prevent burn-out when power is applied to an open circuit breaker which has no gas or air pressure. Circuit breaker trip coils operated by minimum pressure interlocks must be continuously rated to prevent burn out when power is applied to a closed circuit breaker which has no gas pressure.

Alternatively, where continuously rated coils are not provided, the supplier shall provide suitable interlocks to protect the coils.

- 7.6.32 Only line circuit breakers shall be designed for automatic re-closing duty cycles from remote devices as per duty envisaged in these specifications.

7.6.33 **AUXILIARY SWITCHES FOR THE CIRCUIT BREAKER**

Apart from any auxiliary switches normally required in the circuit breakers for control or auxiliary functions as detailed herein, each pole of each circuit breaker shall be provided with eighteen normally open 'a' and eighteen normally closed 'b' switches, all electrically independent and readily convertible from normally open to normally closed operation or vice-versa. Six 'a' and six 'b' switches shall be adjustable for early make or early break operation. An early make 'a' contact connected in series with an early break 'b' contact shall provide a pulse during circuit breaker closing and tripping. The above thirty six switches of each pole shall be cabled by the supplier to terminal blocks in the control cabinet. The contacts shall be capable of interrupting 5A, 220V DC (resistive).

- 7.6.34 For hydraulic operated mechanism, auxiliary switches must be provided with a separate operating device working on the same mechanism. The operation of both mechanisms should be simultaneous.

- 7.6.35 Breakers shall have separate operating devices for each pole and shall be equipped with an electrical phase dis-agreement circuit, complete with a time delay relay with adjustable setting. The relay shall provide automatic 3-phase tripping of the circuit breaker or single pole tripping in case of line breaker if desired and shall have a normally open contact wired to the control cabinet terminal block.

- 7.6.36 The supplier shall supply all relays, switches and accessories to provide for fail-safe operation of the circuit breaker under conditions of low stored energy where stored energy(oil) is used for operation. The circuit breaker shall have local storage sufficient for a duty cycle following the loss of supply to the main energy storage system. The recharging time following the restoration of the supply shall be less than 30 minutes". Low stored energy in any pole shall initiate at:-

- | | | |
|----|---------|--|
| a) | Level 1 | Low stored energy (pressure) alarm. |
| b) | Level 2 | Initiate blocking of breaker closing when stored energy is insufficient to perform a close-open duty cycle. |
| c) | Level 3 | Initiate automatic circuit breaker tripping and isolation at a point where sufficient stored energy is still available to perform the operation. |

- 7.6.37 For hydraulic operations the supplier shall supply the controls.

- 7.6.38 The supplier shall explain the features incorporated in the circuit breaker control mechanism to supervise the operation of opening of each pole of the breaker. A pole discordance alarm shall be provided for annunciating.

- 7.6.39 Means shall be provided to mechanically block the operating mechanism so that adjustments may be made safely.
- 7.6.40 All auxiliary devices, such as heater, receptacles, etc. shall be suitable for connection to the power sources as follows:-
- a) 240 V AC Single Phase - 50 Hz.
 - b) 415 V AC 3-Phase, 4-Wire, 50 Hz.
- 7.6.41 The SF6 gas insulated circuit breaker shall have the following performance characteristics and ratings, in addition to those stated in clause 7.4.
- a) Type of breaker 420 kV rated voltage three phase metal enclosed, SF6 gas insulated hydraulic/spring operated.
 - b) Rated normal current A
 - i) Generator, Transformer 800 Amps
 - ii) Line breakers 2000
 - iii) Bus coupler 4000
 - c) Number of poles 3
 - d) Installation Indoor
 - e) Temperature rise As per Table 3 of IEC 694 (1980)
 - f) Rated short circuit current, KA (rms value of ac component). (for 1 sec) 50
 - g) Rated short circuit making current, KA (peak) 125
 - h) System Neutral Earthing Effectively earthed
 - i) First-pole-to-clear factor 1.3
 - j) Rated duration of S.C. 1 Second
 - k) Total break time for any current Upto the rated breaking current. Not exceeding 50ms.
 - l) Closing time Not exceeding 100 ms
 - m) Difference in the instants of closing/opening of contacts:
 - i) Within a pole Not exceeding 5 ms.
 - ii) Between poles Not exceeding 10 ms.
 - n) Rated transient recovery voltage for terminal faults. As per IEC 56-(1987)

o)	Rated characteristics for short line faults.	As per IEC 56-(1987)
p)	Standard values of rated line characteristics for short line faults.	As per IEC 56-(1987)
q)	Rated operating duty cycle	
	i) Line breakers/bus coupler breaker	O-0.3 s-CO-3 min-CO
	ii) Generator transformer breaker	O-3 min-CO-3min-CO
r)	Auto reclosing (Line breakers only)	Single-phase and 3-phase.
s)	Operating mechanism	Hydraulic/spring
t)	i) Number of trip coils	2 per pole
	ii) Number of closing coils	1 per pole
u)	SF6 gas characteristics for SF6 circuit breaker.	As per IEC 376
v)	Rated line charging breaking capacity	400 A with temporary over voltage as high 2.0 p.u. without restrikes.
w)	Small inductive breaking current	i) Three phase 84 MVA transformer magnetizing current. ii) Any value from 0.5A to 10A without switching over voltage exceeding 2.3 p.u. whichever is severe.
x)	Control of switching surge	Switching surge over-voltage while re-energizing shall limit for 2.3 p.u.
y)	Radio interference voltage at 266 kV (r.m.s.)	=<2,500 micro volts.
z)	Corona extinction voltage kV (r.m.s.)	320
aa)	Partial discharge level pico coulombs.	10 or less

- | | | |
|-----|---------------------------|---|
| ab) | No. of auxiliary contacts | 18 NO and 18 NC in each pole wired to terminal block-control cabinet. |
| ac) | Main contact material | Cu-silver. |

The governing data for the selection of circuit breakers are not only those listed above but also those that can be readily calculated from these documents. The circuit breakers must be suitable for their intended service and location for all no load, full load and fault service conditions.

7.7 ISOLATOR SWITCHES

- 7.7.1 Isolator switches shall be of the 3-phase, single-pole, group-operated type, installed in the switchgear in locations as shown on the single line diagram to provide electrical isolation of the circuit breakers from the transformer, double bus and transmission lines. The isolators shall be electric motor operated suitable for use on 220 V DC ungrounded system and shall be equipped with a manual operating mechanism for emergency use. The motors shall be protected by circuit breaker.
- 7.7.2 The disconnecting switches shall be arranged such that the three phases operate simultaneously. All parts of the operating mechanism shall be able to withstand without damage the full starting torque of the motor mechanism until the motor overload protection operates.
- 7.7.3 It shall be possible to operate the disconnecting switches manually by cranks or hand wheels. In the manual position the power operator shall be both mechanically and electrically disconnected.
- 7.7.4 Every dis-connector located in the generator and line bay shall be designed to break the capacitive charging currents when opening. Contact shielding shall be designed to prevent high local stresses caused by the transient recovery voltages when these currents are interrupted. The bidder should describe the contact shielding in detail.
- 7.7.5 The switch operating mechanisms shall be complete with all necessary linkages, clamps, couplings, operating rods, support brackets and grounding devices. All bearings shall be permanently lubricated or shall be such that no lubrication or maintenance is required.
- 7.7.6 Opening and closing of the isolators shall be either by local or remote control. Local operation shall be by means of a two-position control switch located in the bay module control cabinet.
- 7.7.7 Remote control through the Remote/local transfer switch will be from the power house control room.
- 7.7.8 The isolator operations shall be interlocked electrically with the associated circuit breakers such that the isolator control is inoperative if the circuit breaker is closed. Actuation of the emergency manual operating device shall also disable the electrical control circuits, and shall be key interlocked with the associated circuit breakers.

- 7.7.9 Each isolator switch shall be supplied with 18 (eighteen) normally open and 18 (eighteen) normally closed auxiliary switches for other use over and above those required for switchgear interlocking purposes. Also, it shall be possible to change normally open contact into normally closed contact and vice versa.
- 7.7.10 Signaling of the isolator closed position shall not take place unless it is certain that the movable contacts will reach a position in which the rated normal current, peak withstand current and short-time with-stand current can be carried safely.
- 7.7.11 Signaling of the dis-connector open position shall not take place unless the main contacts are fully separated.
- 7.7.12 The auxiliary switches and auxiliary circuits shall be capable of carrying a current of at least 10A DC continuously.
- 7.7.13 Auxiliary switches shall be capable of breaking at least 2A in a 220 V DC circuit with a time constant of not less than 20 milliseconds. Auxiliary switches shall be positively driven in both directions.
- 7.7.14 Isolator provided with safety grounding switches shall have mechanical key and electrical interlocks to prevent closure of the grounding switches when the isolator switches are in the closed position and to prevent closure of the isolator switch when the grounding switch is in the closed position.
- 7.7.15 Isolator provided with high-speed fault make grounding switches will be interlocked such that the fault make switches close first to discharge the radial cable or line charging currents before the respective isolators may be opened.
- 7.7.16 When the lines are taken out of service for maintenance, etc., the isolators and high-speed grounding switches located on the transmission line feeder modules of the Gas Insulated Switchgear are required to operate as follows:
- After tripping of circuit breaker, operation of the respective isolator control switch to open will first initiate rapid closure of the associated high-speed grounding switch. When this grounding switch is signaled to close by its auxiliary switches, an adjustable time delay relay will start to allow time for any trapped charges to dissipate into the grounding network.
- At the conclusion of the time delay, the isolator operating motor operating mechanism will be energized to open the isolator.
- Operation of the isolator control switch to close will close the isolator, which when proved closed, will signal the high-speed grounding switch to open.
- 7.7.17 Local control of the isolators and high-speed grounding switches from the bay module control panel will be from individual control switches with the Remote/Local transfer switch set to local.
- 7.7.18 All electrical sequence interlocks will apply in both remote and local control modes but in local mode the time delay relay will be blocked.
- 7.7.19 Each isolator switch shall have a clearly identifiable local, positively driven mechanical position indicator, together with remote position indicator on the

bay module control cabinet and remotely in the power house control room.
The indicator shall have the following wording and colouring:-

	<u>Sign</u>	<u>Background Colour</u>
	Open position	Green
	Closed position	Red
7.7.20	All the disconnecting switches shall have endoscopic arrangement allowing easy visual confirmation from outside the enclosure of full travel of the switch contacts to both of the open and close positions.	
7.7.21	The disconnecting switches shall be provided with rating plates, and shall be accessible for inspection.	
7.7.22	The disconnecting switches shall be capable of being padlocked in both the open and closed positions with the operating motor automatically disengaged. The padlocking device shall be suitable for a standard size lock with a 10mm shank. The padlock must be visible and directly lock the final output shaft of the operating mechanism. Integrally mounted lock when provided shall be equipped with a unique key for such three phase group. Master key is not permitted.	
7.7.23	The control and power cables will terminate, at one point for each 3-phase disconnecting switch. It will be the supplier's duty to supply all equipment needed to extend from this point to the individual phases. All mechanism cabinets shall have heaters rated 240 V A.C.	
7.7.24	The isolators shall conform to IEC-129 and shall have the following ratings and performance characteristics in addition to those stated in Clause 7.4.	
	a) Rated insulation level	As per Clause 7.4
	b) Power frequency withstand voltage across Open gap, for 1 min.	610 kV
	c) Impulse withstand voltage across Open gap	1665 KVp
	d) Switching Impulse withstand voltage	1245 KVp
	e) Rated normal current,	
	i) Generator Transformer module	800 Amps
	ii) Line module	2000 Amps.
	iii) Bus coupler & bus sectionalizer module	4000 Amps.
	f) Rated supply voltages of closing devices and auxiliary circuits	220 V DC un-grounded; 240 V, 50 Hz,

single-phase
415 V, 50 Hz,
three-phase

AC.

g) Total operating time of isolator alongwith its operating mechanism.	Not to exceed 12 s
h) Rated magnetizing/capacitive current make And break capacity.	As per relevant IEC.
i) Partial discharge level	=<10 pico coulombs
j) Corona extinction voltage	320 kV (r.m.s.)
k) Radio interference voltage at 266 kV(r.m.s.)	=<2,500 microvolts
l) Total operating time of dis-connector after the command is given.	Not to exceed 15sec

7.7.25 The Supplier shall offer only the dis-connectors which are proved against the effect of VFT (dis-connector switching and very fast transients).

7.8 SAFETY GROUNDING SWITCHES

- 7.8.1 Three phase, group operated work in progress safety grounding switches shall be provided as shown on the single line diagram. Each grounding switch group shall have a single electric motor suitable for operation from a 220 V DC ungrounded supply. Means of emergency manual operation shall also be provided.
- 7.8.2 In order to provide test facilities, certain ground switches may be required to be insulated from the enclosures and have easily removable ground connections.
- 7.8.3 Each safety grounding switch shall be electrically and mechanically key interlocked with its associated isolator switch and circuit breaker such that it can only be closed if both the circuit breaker and isolator switch are open.
- 7.8.4 Safety ground switch operation shall be achieved locally from the bay module control cabinet only; remote control is not required.
- 7.8.5 Positive mechanical position indication shall be provided locally at each switch and remotely at each bay module control cabinet, and in the power house control room.
- 7.8.6 The indicator shall have the following wording and colouring:-

	<u>Sign</u>	<u>Background Colour</u>
Open position	Open	Green
Closed position	Close	Red

- 7.8.7 Interlocks shall be provided such that manual operation of the switches or insertion of the manual operating device will disable the electrical control circuits.
- 7.8.8 Each ground switch shall be fitted with six normally open and six normally closed auxiliary switches for other use over and above those required for local interlocking and position indication purposes.
- 7.8.9 Provision shall be made for padlocking the ground switches in either the open or closed positions.
- 7.8.10 All portions of the grounding switch and operating mechanism requiring grounding shall be properly grounded.
- 7.8.11 The main grounding connection on each grounding switch shall be rated to carry the full short circuit rating of the switch for 1 second and shall be equipped with a silver-plated terminal connector suitable for connection to the switchyard grounding grid.
- 7.8.12 The safety grounding switches shall conform to the requirements of IEC 129.

7.9 HIGH SPEED, MAKE PROOF GROUNDING SWITCHES

- 7.9.1 Grounding switches located at the entrances of the transmission lines and transformer feeder circuits shall be of the high-speed, make proof type and will be used to discharge the respective charging currents, in addition to their safety grounding function. These grounding switches shall also be capable to interrupt the inductive and capacitive currents and to withstand the associated TRV.
- 7.9.2 These Three phase switches shall be group operated from a single electric motor operator suitable for operation from a 220 V DC ungrounded supply.
- 7.9.3 The switches shall be fitted with a stored energy closing system to provide fault making capability.
- 7.9.4 The short circuit making current rating of each ground switch shall be equal to its peak withstand current rating of 125 KA.
- 7.9.5 Each switch shall have a positive local mechanical position indicator, a remote indicator at the bay module control cabinet and remote indication in the power house control room.
- 7.9.6 The indicator wording and colouring shall be as follows:-

	<u>Sign</u>	<u>Background Colour</u>
Open position	Open	Green
Closed position	Close	Red

- 7.9.7 High speed ground switch operation shall be obtained locally from the bay module control cabinet, or remotely from the power house control room in conjunction with opening of the associated isolator switch.
- 7.9.8 The high speed grounding switches shall be electrically and mechanically key interlocked with their associated circuit breakers such that the grounding

switches cannot be closed if the circuit breakers are closed. The grounding switches will be required to close before the isolator switches are open in order to dissipate the trapped charges, when the lines are taken out of service for maintenance, etc.

- 7.9.9 Interlocks shall be provided such that insertion of the manual operating devices will disable the electrical control circuits.
- 7.9.10 Each high speed ground switch operator shall be fitted with six normally open and six normally closed auxiliary switches for local interlocking and position indication. All contacts shall be wired to terminal blocks in the local bay control cabinet. Provision shall be made for padlocking the grounding switches in either the open or closed position.
- 7.9.11 All portions of the grounding switches and operating mechanism requiring connection to ground shall be properly grounded, by using flexible copper conductor having minimum cross section area of 50mm².
- 7.9.12 The main grounding connection on each grounding switch shall be rated to carry the peak withstand current rating of the switch for 1 s and shall be equipped with a silver plated terminal connector suitable for connection to the switch yard grounding grid.
- 7.9.13 The high speed make proof grounding switches shall conform to the requirements of IEC 129.

7.10 CURRENT TRANSFORMERS

- 7.10.1 The current transformers incorporated into the GIS will be used for protective relaying and metering and shall be metal enclosed type. The secondary leads shall be brought out through a gastight bushing plate into the secondary terminal box. All current transformers shall have effective electromagnetic shields to protect against high frequency transients.
- 7.10.2 A current transformer marshalling terminal box shall be provided and located in an accessible position for connections of each phase. The marshalling box shall be used for the star/delta configuration and be equipped with terminals with short circuiting facility for the secondary circuits.
- 7.10.3 The wiring between each current transformer core to marshalling terminal box to protection panels and to other required places are required to be done as per scheme. **The parameters would prevail as per the approved SLD attached.**

7.10.4 .1 Generator transformer Module

	U-08	U-09	U-010
No. of CT's	3	3	3
No. of cores	2	5	1
Rated primary current	4000-2000-1000A	150A	150A
Rated secondary current	1.0 A	1.0A	1.0A
Rated voltage	420 kV	420 kV	420 kV

Other parameters:-

	CT-U_12		CT-U_13					CT-U_11
Purpose	Bus Bar Differential A	Bus Bar Differential B	Generator Transformer overall differential Protection	Differential Protection of Transformer	Metering	Transformer Overcurrent Protection	Local Breaker Back-up Protection	Restricted Earth Fault Protection
Core	I	II	I	II	III	IV	V	I
Burden	-	-	-	-	30VA	5VA	5VA	-
Knee point Voltage /ALF	$\geq 1200V$	$\geq 1200V$	$\geq 200V$	$\geq 200V$	-	-	-	$\geq 200V$
Accuracy Class	PS	PS	PS	PS	0.2(ISF \leq 3)	5P20	5P20	PS
Max. Secondary Resistance	≤ 20 ohms at 4000A tap	≤ 20 ohms at 4000A tap	≤ 1.5 ohms	≤ 1.5 ohms	-	-	-	≤ 1.5 ohms
Exciting Current (mA)	<30 at VK/2	<30 at VK/2	<30 at VK/2	<30 at VK/2	-	-	-	<30 at VK/2

.2 Feeder Line Module

	CT LY01	CT LY02
No. of CT's	3	3
No. of cores	3	2
Rated primary current	2000-1000A	4000-2000-1000A
Rated secondary current	1.0A	1.0A
Rated voltage	420 kV	420 kV

Other parameters:

	CT-LY01			CT-LY02	
Purpose	Main-I Protection	Main-II Protection	Metering	Bus Bar Differential	Spare
Core	I	II	III	I	II
Burden	-	-	50VA	-	-
Knee point Voltage /ALF	$\geq 2000V$	$\geq 2000V$	-	$\geq 1200V$	$\geq 1200V$
Accuracy Class	PS	PS	0.2(ISF \leq 3)	PS	PS
Max. Secondary Resistance	≤ 10 ohms at 2000A tap	≤ 10 ohms at 2000A tap	-	≤ 20 ohms at 4000A tap	≤ 20 ohms at 4000A tap
Exciting Current (mA)	≤ 30 at VK/2 at 2000A tap	≤ 30 at VK/2 at 2000A tap	-	≤ 30 at VK/2 at 4000A tap	≤ 30 at VK/2 at 4000A tap

3. Bus Coupler Module

	BC-A	BC-B
No. of CT's	3	3
No. of cores	3	3
Rated primary current	4000-2000-1000A	4000-2000-1000A
Rated secondary current	1.0 A	1.0 A
Rated voltage	420 kV	420 kV
Accuracy class for core-III	5P20	0.2

Other parameters: Common for both bus A & bus B CT's

Purpose	Bus bar Differential Bus	Bus bar differential Bus	Local breaker back- up for bus A & spare for bus B
Core	I	II	III
Rated burden	-	-	50 VA
Accuracy class	PS	PS	As indicated above
Knee point Voltage Volts/ALF	≥ 1200 V	≥ 1200 V	-
Max. CT Secondary Resistance At 4000/1 A	≤ 20 ohms	≤ 20 ohms	-
Exciting Current (mA)	≤ 30 at $\frac{VK}{2}$	≤ 30 at $\frac{VK}{2}$	-

7.10.5 The particulars of the various cores are likely to change within reasonable limits. Manufacturer is required to have these values confirmed by purchaser before proceeding with design of the cores. Provision shall be made either with in the current transformers or out side for primary current injection testing. Other characteristics of CTs shall be as given below:-

- | | | |
|----|--|-------------------|
| a) | Rated short time thermal current for 1 s, kA (rms) | 50 |
| b) | Rated dynamic current kA (peak) | 125 |
| c) | Rated insulation levels | As per clause 7.4 |
| d) | Power frequency overvoltage | As per IEC 185 |

	withstand requirements for secondary windings	
e)	Limits of temperature rise	As per IEC-185, Table 1
f)	Maximum Radio Interference voltage at 266 kV (r.m.s)	<2,500 Microvolt
g)	Corona extinction voltage kV (r.m.s.)	320
h)	Partial discharge level	<10 pico-coloumbs

7.11 VOLTAGE TRANSFORMERS

- 7.11.1 Single phase voltage transformer shall be located on the 420 kV bus-A & bus-B in SF6 switchgear.
- 7.11.2 The voltage transformer shall be effectively shielded against high frequency electromagnetic transients.
- 7.11.3 The voltage transformer secondaries shall be wired by manufacturer to their associated secondary circuit breakers in the bay module control cabinets to the line protection panels and to other required panels as per the scheme.
- 7.11.4 The voltage transformers shall conform to IEC-186/IS-3156 and shall have the following ratings, in addition to those mentioned in Clause 7.4.

	WINDING-I	WINDING-II	WINDING-III
Rated secondary Voltage, V	$\frac{110}{\sqrt{3}}$	$\frac{110}{\sqrt{3}}$	$\frac{110}{\sqrt{3}}$
Rated secondary Burden VA	50	50	50
Accuracy class	3P	0.2	0.2
Utilisation	Protection, Metering and Synchronizing		
Transformer ratio	$\frac{420 \text{ kV}}{\sqrt{3}} / \frac{110 \text{ V}}{\sqrt{3}} / \frac{110 \text{ V}}{\sqrt{3}} / \frac{110 \text{ V}}{\sqrt{3}}$		
Temperature rise	As per IEC 186		
Voltage factor	1.5 for 30 sec.		
Rated insulation Level.	As per Clause 7.4		

7.12 SF6 BUSHING CONNECTION

7.12.1 SF6-TO-AIR BUSHINGS

7.12.1.1 The 400 kV overhead lines are to be connected to SF6 GIS by AIR-SF6 gas filled bushings through 400 kV Bus Ducts. The air terminations shall consist of a porcelain shell which encloses the conductor & an appropriate ground sleeve. The shell shall be sealed to aluminium flanges by elastomer seals. The conductor shall be provided with a plug in contact to accommodate thermal expansion and facilitate replacement of the bushing shell without disturbing welded line sections.

7.12.1.2 The bushing shall employ capacitive grading and be divided into independent gas compartments by a barrier insulator with grading electrodes. The space surrounded by the porcelain insulator shall be filled with SF6 gas slightly above atmospheric pressure. In case the porcelain is damaged, this shall keep consequences down to a minimum. The gas space on the switchgear side of the barrier insulator shall have the same SF6 gas pressure as that of switchgear.

7.12.1.3 The Air/SF6 bushing shall conform to IEC-137 and IS-2099 (latest edition) and shall have the following rating:

- | | | | |
|----|------------------------------------|---|----------------|
| a) | Lighting impulse withstand voltage | - | 1425 kV (Peak) |
| b) | Switching surge withstand voltage | - | 1175 kV(Peak) |
| c) | One minute power frequency | - | 630 kV (RMS) |

The copy of the type test certificates shall be supplied along with the offer.

7.12.1.4 The SF6-to-Air bushing shall be SF6 gas-insulated type and shall be suitable for the indoor ambient conditions stated in Section-3 of these specifications. If the bushing of condenser type with grading elements are offered, these shall be fitted with capacitance taps for the measurement of tan delta and partial discharge. The test sockets shall be brought out to an accessible location on the mounting base.

7.12.1.5 All porcelain used in the bushings shall be manufactured by the wet process and shall be homogeneous, free from laminations, cavities or other flaws affecting its mechanical strength or dielectric quality, and shall be well vitrified, tough and impervious to moisture. The glazing of the porcelain parts shall be free from imperfections such as blisters and burns. All bushings shall be so designed that there will be no stressing of any parts due to temperature changes and adequate means shall be provided within the support structures to accommodate bus-duct enclosure and conductor expansion.

- 7.12.1.6 All contact surfaces of external terminals shall be silver-plated using pure silver.

The bushing shall be hermetically sealed and be impervious to impurities and moisture during shipment and storage. Suitable supporting structures of galvanized steel for the bushings and bimetallic terminal connectors connecting overhead conductors shall be provided by manufacturer.

The SF6-to-air bushings which shall be complete with suitable corona rings, shall conform to IEC-137 and IEC-506 and shall have the following technical particulars, in addition to those stated in clause 7.4

Rated current	2,000 Amps.
Rated short time current (rms)	50 kA for 1 sec.
Rated frequency	50 Hz $\pm 3\%$
Rated insulation level	As per clause 7.4
Temperature rise	As per IEC-137
Minimum creepage distance	6720 mm
Corona extinction voltage	320 kV (rms)
Radio interference level at 266 kV (rms)	Less than 2,500 Microvolts
Partial discharge level	Less than 10 pico-coulomb

7.12.2 **SF6-TO-OIL BUSHINGS**

- 7.12.2.1 The interface section from the SF6 bushings of the generator transformers to the GIS system shall form a part of the supply by the GIS supplier and shall provide the transition section between the enclosure of SF6 equipment and the SF6 bushing of the transformer. The region adjacent to the transformer termination shall meet the minimum requirement as deemed necessary by the transformer manufacturer. The ducts and the casing shall be suitable for the requirements for which it is designed. The supplier should specify the forces which shall be transmitted to the SF6 bushing of the transformer. The supplier

shall have to supply all details for proper co-ordination with the transformer manufacturer covered in other section of the document. This interface section shall be designed in a manner which will allow ease of operation and maintenance.

- 7.12.2.2 Provision shall exist for a removable link. The gap created when the link is removed should have sufficient dielectric strength to withstand the switchgear high voltage site tests. The supplier may suggest alternative arrangements to meet these requirements. The corona rings/stress shields for control of electrical field in the vicinity of the isolation gap shall be provided by the GIS manufacturer.
- 7.12.2.3 The filled and minimum SF6 gas pressure within the termination compartment at the junction of the transformer bushing and the SF6 duct shall be within the limit specified by the transformer manufacturer to ensure correct environment for the SF6 bushing termination.
- 7.12.2.4 The SF6 manufacturer shall submit details alongwith the offer regarding the forces which shall be transferred on to the SF6 bushings of the transformers to enable proper co-ordination between the transformer and the GIS manufacturer.
- 7.12.2.5 All supporting structures for the SF6 duct connections between the transformer and the GIS shall be supplied by the GIS supplier. The supplier may specify alternative arrangements for approval by the purchaser.
- 7.12.2.6 Forces generated during the operation of transformer, those generated in the enclosure and the conductors of the SF6 equipment shall not exceed the allowable limit specified by the transformer manufacturer.
- 7.12.2.7 Precise positional alignment of the enclosures is of crucial importance. The location and tolerances for the connection between the transformer and the GIS equipment shall be specified by the transformer supplier. The GIS supplier is required to make provision for alignment and positional adjustment within the equipment.
- 7.12.2.8 Sufficient CGI bus shall be supplied to connect together the various items of equipment. Bus stubs with appropriate caps shall be provided.
- 7.12.2.9 The connection at transformer shall allow at least 25mm of movement in any direction. Access openings shall be provided in each phase terminal enclosures as necessary to permit removal of connectors to isolate the step-up transformer to allow performance to insulation tests. The typical arrangement drawing of CGI Bus duct to step-up transformer bushing housing connection shall be supplied for approval by the purchaser. The interface equipment shall incorporate following features.
- i) Housing to cover the transformer H.V. side oil to SF6 bushing. The housing shall be filled with SF6 gas after assembly.
 - ii) Bus with barrier insulator and flexible connection between transformer H.V. terminal & SF6 bus duct conductor.
 - iii) The lateral mounting unit suitable to allow axial assembly tolerances and to allow the transformers to be easily connected to or disconnected from the switchgear.

- iv) Compensators to avoid transfer of the transformer vibrations to the switchgear.

7.13 SURGE ARRESTORS

7.13.1 SF6 gas insulated, metal enclosed surge arrestors of the gapless metal oxide, heavy-duty, station type shall be located on H.V. side of generator transformers and before SF6-To-Air Bushings in Line Feeders. At line ends open type gapless metal oxide arrestors in GIS shall be provided.

7.13.2 The arrestor tanks shall be vertically or horizontally mounted to best suit Manufacturer's switchgear layout, and shall be fitted with pressure relief vents directed away from areas frequently used by operating personnel. Each arrestor unit shall be fitted with a discharge counter located in an easily accessible position.

7.13.3 Each arrestor shall conform to IEC-99-4 and draft IEC TC 37 WG 4 for Gapless arrestor where applicable and shall have the following technical performance characteristics and ratings, in addition to those stated in clause 7.4.

- | | | |
|----|---|---|
| a) | Rated voltage of arrestor | 336 kV (rms) |
| b) | Class of diverter | Station type, heavy duty SF6 gas insulated, metal oxide, gapless. |
| c) | Maximum continuous voltage capability, (L-N), | 273 kV (rms.) |
| d) | Maximum discharge current (8/20 microsecond wave) | 20kA |
| e) | Maximum switching surge protective level | 661 kV (Peak) |
| f) | Maximum residual voltage (discharge voltage) at 10 KA (8/20 microsecond current Wave) | 800 kV (Peak) |
| g) | Maximum equivalent front-of wave protective level, (10 KA with voltage wave cresting in 0.5 microsecond). | 882 kV (Peak) |
| h) | Impulse withstand voltage of equipment to be protected: | |
| | i) Transformers | 1,300 kV (Peak) |
| | ii) GIS component | 1,425 kV (Peak) |
| i) | Switching surge withstand voltage of equipment to be protected. | 1.050 kV (Peak) |
| j) | Radio interference voltage | Not exceeding 2,500 |

	at 226 kV (RMS)	micro-volts.
k)	Partial discharge level	20 or less pico coulombs
l)	Corona extinction voltage	320 kV (rms)
m)	Energy level	10 KJ/kV

Arrestor Duty

- | | | |
|-----|-----------------------------------|---|
| i) | Connection to system: | Phase to earth |
| ii) | Type of equipment being protected | : a) Generator step up transformer.
b) Line switchgear bay |

Additional equipment and fitting:

- i) Whether metal enclosed arrestor is required - Yes
- ii) Type of mounting (pedestal, bracket, hanging) Bidder should study the layout and offer most suitable type of mounting. The reason for selecting particular type of mounting shall be explained in the bid.
- iii) Mounting orientation, if other than vertical :- Bidder to decide best orientation.

The bidder shall select the technical parameters and characteristics of the surge arrestor so as to obtain a security ratio of at least 1.30 under all conditions of over voltages and the basic insulation provided for the transformer winding. The bidder shall furnish alongwith his bid report containing the technical justification and calculations in support of the selection of the location and other technical parameters of the surge arrestor.

This study report should highlight the technical comments on the proposed rated voltage, the long duration class and the energy handling capacity.

- 7.13.4 The manufacturer shall perform an insulation co-ordination study to verify that protection of switchgear and main transformers against over voltages is adequate. The final surge arrestor characteristic their numbers and exact locations of surge arrestors shall be decided upon after this study.

Arrestors located in outdoor yard:

The GIS located in indoor/outdoor will be connected to the transmission lines by 420 kV interconnection. For protection of GIS and 420 kV interconnection, as outdoor type, non linear metal oxide resistor type surge arrestor without spark gaps is provided. These will be located near 420 kV interconnection Pot Head in the outdoor yard as shown in the drawing and are covered in other chapter of the bid document.

7.14 BUS BARS AND BUS DUCTS

- 7.14.1 As per the switching scheme the 420 kV GIS equipment comprising of 11 bays (6 bays in coming from 3-phase 6 Nos. 84 MVA transformers, one bus coupler bay and 4 outgoing bays) shall be located at El 889.00 m approx. in a power house building. The bus bars connection shall be single phase encapsulated laid in horizontal configuration. Further, the take off point at the Pot Head Yard shall be connected with the line switchgear bus ducts through SF6/air bushings as per layout (tentative) drawing attached with the document.
- 7.14.2 The conductors of the bus bars and bus ducts shall be fabricated of aluminium of cross-sectional area suitable to meet the current rating requirements. The tubular bus sections shall be housed in aluminium enclosures, filled with pressurized SF6 gas. The conductors shall be supported from the enclosures by homogenous epoxy resin insulators shaped to ensure uniform electrical field distribution and zero corona at rated voltage. Adequate provision shall be made for absorption of the thermal expansion of the conductors and of differential thermal expansion between the conductors and the enclosures. Metal bellow type compensators with adjustable tensioners shall be provided where required. The enclosures shall be designed to eliminate as much as possible all external effects of the flux created by normal and fault currents. The power losses in the system shall be kept to a minimum and induced voltages on the enclosures shall not be allowed to exceed reasonable limits of safety for operating personnel.
- 7.14.3 Bus end connections shall be made with multi-contact connectors to allow ;for axial thermal expansion of the bus. Enclosure and connections shall be flanged and shall be fitted with gaskets or O-ring seals to provide an effective gastight joint between sections.
- 7.14.4 Each end of the main bus bars shall be designed for convenient future extension of the switchgear. Bus conductor and connectors and enclosure flanges shall be designed accordingly.
- 7.14.5 All necessary indoor and outdoor galvanized steel supporting structures for the proper erection, leveling and alignment of the bus bars and bus ducts shall be provided by Manufacturer.
- 7.14.6 Provisions shall also exist for the connection to the SF6 bushings of the transformer. The actual length of the bus duct would be finalized after layout is frozen. For any change in length for bus duct shall have no financial implication on the purchaser.
- 7.14.7 The buses shall have continuous current rating of 4000 Amps for 400 kV.
- 7.14.8 The system employed shall be of the electrically continuous enclosure type, allowing free circulation of induced currents in the enclosures. The enclosures shall be cylindrical in shape and designed for maximum shielding to minimize electro-magnetic forces caused by short circuit currents.
- 7.14.9 Where the CGI bus passes through building, walls, flooring or other enclosures, the supplier shall supply the wall plates, flanges and all bolts.

- 7.14.10 The SF6 Bus duct will be naturally ventilated and no forced ventilation/cooling is envisaged.
- 7.14.11 Wherever necessary, to absorb expansion, contraction, relative movement between the various items of equipment and also the earth quake forces, bellows or other means shall be provided. Supplier must submit details alongwith the offer.
- 7.14.12 The bus shall be provided with all necessary supporting steel structure.
- 7.14.13 The "Interface" arrangements between the equipment shall be in the scope of GIS supplier.
- 7.14.14 Each gas compartment barrier shall be easily identifiable from the outside of the switchgear. The means of identification used shall be a black band, approx. 10mm wide, permanently affixed to the barrier insulator on outer surface of the bus duct at the location of the barrier insulation. In case of leakage of gas from any compartment, selective indicator should be made on the annunciator.

7.14.16 PENALTIES

- i) The bidder shall indicate guaranteed maximum values of losses & further indicate whether losses are firm or subject to tolerance. In case losses are subject to tolerance, ceiling shall be indicated for tolerance.
- ii) Tenders will be evaluated for the guaranteed losses based on the calculations. The capitalization of guaranteed losses for bus bars & enclosures shall be evaluated at Rs.1,40,000 per K.W. The bidder shall furnish detailed calculations for the guaranteed losses. For the purpose of capitalization of the losses, length of 4000A double bus bar of Gas Insulated Switchgear shall be considered 110m as specified in the specification drawing.
- iii) On testing if it is found that actual losses are more than the values quoted, including maximum tolerance specified, if any, the penalty will be imposed on the supplier @ Rs.2,80,000 for each K.W. in excess to losses & recovered.
- iv) The purchaser reserves the right to reject the bus ducts if the losses exceeds the declared losses beyond 5%. In case temperature rise of bus bars and enclosures exceeds the guaranteed values, quoted by the supplier, the purchaser also reserve the right to reject the bus duct.

7.15 CONTROL EQUIPMENT

7.15.1 CIRCUIT BREAKER ACCESSORIES/AUXILIARY EQUIPMENT

The accessories and auxiliary equipment to be supplied with the circuit breaker shall include all parts necessary for correct functioning of the circuit breaker such as:-

- a) Operation counter, electrically operated.

- b) One set of adequately rated, thermostatically controlled, anti-condensation heaters with provision for monitoring of heater failure, wired to terminal blocks.
 - c) Two copper ground bus bar to be located near the control cable entrance.
 - d) Operating mechanism, pressuring unit, gauges and switches.
 - e) All motor driven auxiliaries shall have individual phase or pole thermal over-current protection.
 - f) Circuit breaker SF6 gas pressure monitoring unit.
 - g) One vermin proof, sheet steel cabinet of adequate size shall be provided for housing the operating mechanism, relays, control and auxiliary equipment and for terminating all control, alarm and auxiliary circuits on suitable terminal blocks. The control cabinet shall be provided with hinged doors with provision for locking and removable cable gland plates for bottom cable entry. Viewing windows shall be provided for observation of the instruments without opening the cabinet. Suitably engraved name plates shall be provided to identify all equipment in the control cabinet.
- 7.15.2 All control wiring and terminations internal to the switchgear and connecting the switchgear to the bay module control cabinets shall be provided by manufacturer.
- 7.15.3 All control cables shall be provided with double metallic shield. The external shields shall be grounded at both ends and the internal at one end only. Grounding connections shall be as short and direct as possible and shall terminate at the point of entry to cabinets or terminal boxes.
- 7.15.4 Coaxial type cable glands suitable for use with shielded cable shall be used at each termination.
- 7.15.5 All control shall be installed and terminated in such a manner as to limit the effects of transient electromagnetic voltages on the control conductors to an acceptable level.
- 7.16 BAY MODULE CONTROL CABINETS**
- 7.16.1 Each switchgear bay module shall be supplied with a main control cabinet of the floor standing type. The cabinet shall have double, full height, hinged, gasketed, lockable doors. One door shall have a safety glass window through which the various switch gear controls can be viewed without opening the doors.
- 7.16.2 The panel will be utilized as both the switchgear bay local control and as the terminating center for all power supply, control annunciation and supervisory wiring interfacing with other systems. The A.C. and D.C. power supply for auxiliary and control equipment will be available and it will be as per drawing no. RHEP (E)-514/05 & RHEP (E)-513/05. Further distribution of A.C. and D.C.

power supply shall be arranged by supplier. Two feeders of A.C. and D.C. supply each will be made available as main and stand by feeder for supplying power to one local control panel.

7.16.3 a) Mounted on the cabinet door shall be:-

- i) Remote/local control transfer switch for the circuit breakers and isolator switches.
- ii) Normal operation/maintenance transfer switch for the isolation of remote electrical control.
- iii) Mimic diagram of the switchgear bay complete with semaphore indicators for the switchgear component position indication, and local control switches for open-close or close-trip control of the circuit breaker, isolators and grounding switches.

b) Mounted internally in the Cabinet shall be:

- i) All bay switchgear interlinking wiring and auxiliary relays.
- ii) AC and DC power supply circuit breakers.
- iii) All necessary incoming and outgoing terminal blocks.
- iv) Space heaters.
- v) All instruments and devices required for supervision control of GIS.

7.16.4 The bus voltage transformer secondary terminal circuit breaker will be mounted within the bus VT bay module control cabinet.

7.16.5 Mounted on the solid cabinet door shall be an annunciator panel having sufficient modules and lighted windows to annunciate all gas pressure/density and circuit breaker operating mechanism alarms and trips.

7.16.6 Each annunciator module shall have electrically separate changeover contacts for remote alarm indication. Each remote alarm contact shall be wired to terminal blocks. The annunciator panel shall be complete with an audible warning horn and acknowledge/reset, horn silence and lamp test push buttons. Horn shall automatically silence if the acknowledge button is not operated within 1 minute of the alarm initiating. The lighted window of the fault point shall continue to flash until the acknowledge signal is given. The annunciator panel shall have sufficient modules and lighted windows to annunciate low/high gas pressure/density and all other abnormal conditions also.

The control cabinet shall be suitable for bottom entry of cables.

All the indicating lamps shall be of LED type.

7.17 SUPPORTING STRUCTURE

- 7.17.1 The supplier shall design, fabricate and supply the equipment supporting framework including all rails, transverse and longitudinal beams and supporting members with all necessary hardware and all embedded parts. General structural designs and structural details shall be subject to the approval of the purchaser.
- 7.17.2 The floor of the switchgear building will be adequate to support all loads imposed by the equipment supporting framework. The supplier shall make provision in his designs to minimize transfer of forces resulting from thermal expansion or switchgear operation to the walls, floors of the switchgear building, to facilitate the design of floor of switchgear; the supplier shall supply details of static and dynamic loads alongwith the offer.
- 7.17.3 Non-corrosive metal or cadmium plated steel shall be used for bolts and nuts throughout the work when either or both are subjected to frequent adjustment or removal.
- 7.17.4 All steel structure members shall be hot dip galvanized.
- 7.17.5 All supporting structures shall conform to the following requirements:-

Allow dismantling for the addition of further switchgear components or maintenance of existing equipment without requiring temporary supports.
- 7.17.6 The supplier shall indicate the capacity of the crane required for handling of their equipment.

7.18 SF6 GAS PROCESSING UNIT

- 7.18.1 An SF6 gas 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 by two workers within the switchyard building. "The unit shall be provided with gas testing kit to measure the moisture contents of the gas and with pressure monitoring system. Acidity measurement instrument with nozzle etc. shall also be provided".
- 7.18.2 The unit shall be self-contained (except for additional gas storage, bottles and external power supply at 415 V AC, 3-phase, 50 Hz) and fully equipped with at least an electric vacuum pump, gas compressor, gas drier, gas filter, refrigeration unit, evaporator, gas storage tank, full instrumentation for measuring vacuum on vacuum pump, compressor inlet temperature, tank pressure and temperature, valves and piping to perform the following operations as a minimum requirement:-
- a) Evacuation from a gas filled compartment using the vacuum pump.
 - b) Transfer of SF6 gas from a system at some positive or negative pressure to the storage tank via the gas drier and filter.
 - c) Recirculation of SF6 gas in the storage tank through the drier.

- d) Recirculation of SF₆ gas in any switchgear or bus duct compartment through the drier and filter.
- e) Evaporating and filling SF₆ gas.
- f) Drawing off and liquefying SF₆ gas.
- g) A combination operation of filling SF₆ gas into a gas system and evacuating a second gas system using the vacuum pump.
- h) Pressure monitoring.
- i) Measurement of moisture content & acidity measurement.

7.19 ON-LINE MONITORING

Continuous on line monitoring system shall be provided to monitor conditions such as partial discharge, internal arcing, gas density, gas pressure, gas leakage, moisture (offline) etc. and operating parameters such as current, voltage, temperature etc. of GIS for smooth operation and detection of any changes in insulation at an early stage during normal operation to take appropriate remedial action.

Each system shall be complete with sensors, input/output module, control/processor unit, relays, junction boxes, cabling and associated accessories for measuring, monitoring and data acquisition of intended parameters to be monitored.

7.19.1 Gas monitoring system

Each gas-filled compartment shall have its own SF₆ gas density / pressure monitoring system, each comprising of a temperature compensated SF₆ gas density monitoring unit and pressure gauge having alarm/trip contacts.

Gas pressure and density shall be continuously monitored and displayed by a suitable temperature compensated instrument, which will provide an alarm signal in case of pressure drop before the allowable minimum pressure is reached.

7.19.2 Partial discharge monitoring system

The continuous on line partial discharge monitoring system for permanent supervision of switchgear dielectric condition shall be based on UHF technology.

The system shall have the provision to continuously monitor, record, analyze, diagnose, indicate and trip etc.

The system shall be of an international repute having proven performance and acceptability in the field. The details and scope of the system shall be approved during detail engineering.

7.19.3 Circuit breaker monitoring system

Circuit breaker monitoring system for internal arcing, electrical wear, travel curves shall be provided for information on circuit breaker condition to predict maintenance/servicing.

7.20 ENCLOSURE GROUNDING SYSTEM

The enclosure grounding system shall be designed to minimize circulating currents and to ensure the potential rise is kept to an permissible level.

In addition to the above, the GIS manufacturer shall also indicate their specified recommendations, if any, in respect of grounding so that the same could be taken care.

7.21 STORED ENERGY SYSTEM

7.21.1 Where a stored energy system is required for operation of the switchgear, hydraulic plants for each circuit breaker, shall be in the scope of supplier.

7.21.2 Pressure vessels shall be designed, detailed and constructed in accordance with International Standards.

7.22 TECHNICAL REQUIREMENTS

7.22.1 COMMON REQUIREMENTS

All the SF6 Insulated Circuit Breaker, disconnect earthing switches and bus duct shall be of single phase segregated type.

7.22.2 PROTECTIVE FINISH

The entire exterior surface shall be cleaned and painted, before leaving the factory with one coat of approved primer and two coats (water resistant) of approved finishes. The under-side of all painted surfaces bearing upon the concrete foundation shall be given two coats of approved primer. Extra paint for re-touching shall be made available by the supplier.

7.22.3 FIRE RETARDANCY

7.22.3.1 All components shall be fire retardant and shall be tested in accordance with IEC 695. Gas emissivity when the material is heated shall be minimal. PVC material shall not be used.

7.22.3.2 Control wire in a grouped environment shall not convey flame, continue to burn when tested as per IEC 695. The method of test and criteria for success or failure shall be in accordance with the above IEC.

7.22.4 GROUNDING

7.22.4.1 The GIS Supplier shall define clearly what constitutes the main ground bus of the GIS & bus ducts. The GIS supplier must supply the entire material for ground bus of GIS viz conductor, clamps, joints, operating and safety platforms

etc, to be laid/embedded in GIS floors. The GIS supplier is also required to supply and supervise of erection of all earthing connectors and associated hardware material for;

- i) Connecting all GIS equipment, bus ducts, enclosures, control cabinets, supporting structure etc. to the ground bus of GIS and;
- ii) Connecting ground bus of GIS to the groundmat in power house complex provided by the Purchaser at several points as per equipment.

7.22.4.2 The enclosure of the GIS shall be grounded at several points so that there shall be grounded cage around all live parts. The ground continuity between each enclosure shall be effected over flanges, with links or straps to bridge and flanges. Subassembly-to-subassembly bonding shall be provided to assume safe voltage gradients between all intentionally grounded parts of the GIS assembly and between those parts and the main ground bus of the GIS.

7.22.4.3 A minimum of two nos. of Grounding connections should be provided for each of circuit breaker, transformer, cable terminals, surge arrestors, earth switches and at each end of the bus bars.

7.22.4.4 The enclosure grounding system shall be designed to minimize circulating currents and to ensure that the potential rise is kept to an acceptable level. Each marshalling box, local control panel, power and control cable sheaths and other non current carrying metallic structures shall be connected to the grounding system of GIS via connections that are separated from GIS enclosures.

7.22.4.5 The grounding connector shall be of sufficient mechanical strength to withstand electromagnetic forces as well as capable of carrying the anticipated maximum faults current without overheating atleast for two paths to ground from the main ground bus. Precautions should be undertaken to prevent excessive currents from being induced into adjacent frames, structures of reinforcing steel and to avoid establishment of current loops via other station equipment. Care should be taken to prevent discontinuities in enclosure grounding path at the transformer connections to GIS to prevent circulating currents in the circuit breaker and transformer tank steel.

7.22.4.6 The individual gas insulated Bus duct phase enclosures shall be directly bonded to each other by flexible bonding leads. These bonding leads shall also be the point of attachment for the ground lead. Sufficient bonding and grounding points shall be provided to limit potential rise due to a fault to acceptable values for personnel protection.

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

7.22.4.7 The purchaser will exchange the information regarding the earthing system proposed to be provided. The Supplier shall examine the same and shall advise suitably in the matter.

7.22.4.8 The enclosure shall represent the main grounding inter connection between the several areas. In parallel at least two grounding conductors sized for maximum earth fault current shall be placed. The supplier shall present a detailed proposal for the whole grounding system for approval.

7.22.5 **HIGH VOLTAGE TRANSIENTS**

High voltage transients from switching operations and internal faults are coupled to the external sheath of the GIS. Because the effects of these transients on people are not known, operating personnel are required to avoid contact with the sheath during switching operations. Such a restriction is considered undesirable and the suppliers are requested to comment on devices and techniques which may reduce such hazard or new techniques to reduce transients to an acceptable level.

7.22.6 **BURN THROUGH PREVENTION**

7.22.6.1 The supplier shall explain the design features of their equipment which are intended to prevent burn through when an internal arc occurs. Internal arcing test reports for aluminium enclosures of a similar configuration and wall thickness to the equipment should be included in the offer. The worst case of fault with an arc fixed adjacent to a spacer should be considered and discussed in the offer. The effect of pressure rise and time to burn through should also be discussed for an internal arc. Supplier shall incorporate the latest and most efficient technique of burn through.

7.22.6.2 The supplier is requested to explain techniques that might be used to reduce or eliminate the probability of burn through.

7.22.7 **BOLTING REQUIREMENTS**

7.22.7.1 Details of bolts sizes and threading shall be shown on the appropriate drawings.

7.22.7.2 Where self locking type of nuts are used they shall be of the reusable type. Pressed type nuts are not acceptable.

7.22.7.3 The supplier will be responsible for supplying suitable foundation bolts and clamps as required. He shall also be responsible for grouting the foundation bolts.

7.22.8 **HEATERS**

7.22.8.1 All heaters shall be suitable for connection to a 415 V AC, 3-phase, 4 wire, 50 Hz supply. The heater in the mechanism housing shall be connected inside the housing to this supply and shall be thermostatically controlled. Leads to tank heaters shall be enclosed in conduit.

7.22.8.2 All thermostat and temperature indicating devices shall be calibrated in metric unit.

7.23 SERVICE LIFE

SF6 Circuit breakers, disconnect switches and ground switches will be subjected to frequent, and occasionally repetitive, no load operations and switching of load, capacitive and inductive current within their ratings. In order to minimize maintenance and component replacement, the supplier shall submit proof that all offered SF6 GIS equipment has a minimum service life of 20,000 normal operations/as per relevant IEC/IEEE standard. The maintenance free period for any of its external components shall not be less than 5 years intervals. Internal components including refilling of gas shall not be less than 10 years. The supplier shall propose the recommended period for schedule maintenance.

7.24 WELDING

7.24.1 PRESSURE VESSEL AND PRESSURE PIPE WELDING

The pressure vessel and pressure piping shall be designed and built to the requirement of International Standards for the construction and inspection of Boilers and pressure vessels.

7.24.2 All welding and brazing must satisfy the requirements of the relevant Indian/Internationally accepted Standards.

7.24.3 In addition to the specification, the supplier shall be governed by the following requirements:-

a) All welding procedures to be used in the fabrication of pressure vessels and pipings shall be submitted to purchaser for approval. These procedures must be in consistence with the International Standard.

b) All butt welds shall be full penetration welds.

7.24.4 NON-DESTRUCTIVE EXAMINATION PROCEDURE (NDE)

NDE procedures to be adopted by the fabricator shall be submitted to the purchaser for approval. As a minimum requirement, butt welds on pressure vessels and pressure piping shall be subjected to support radiography inspection.

7.25 INSPECTION & TESTING

7.25.1 GENERAL

7.25.1.1 All equipment, apparatus, materials and supplies provided by manufacturer under this contract shall be subjected to tests in the shop and in the field in the presence of purchaser/consultant or their authorized representatives for conformity to the requirements of the specifications. The method and procedure of the tests shall be as specified for the particular items or shall be in conformity with one of the applicable recognized standards for making such tests. Unless otherwise specified, manufacturer shall perform all shop and field tests. The details of the test procedures and test equipment to be used shall be intimated to the purchaser well in advance.

- 7.25.1.2 Manufacturer shall submit a schedule of the specified testing programme to the purchaser for its approval. Testing of related equipment shall be coordinated so that testing may proceed with a minimum of delay. Performance tests shall start, proceed, stop and be resumed in accordance with the approved schedule.
- 7.25.1.3 Manufacturer shall, at its own expense, promptly make good all defects evident by testing or made apparent in any other way. After defects in the plant have been remedied, the plant will be subjected to such retesting as may be necessary until the plant is proved to be in satisfactory operation.
- 7.25.1.4 Within 30 days of completion of each and every test required as proof of compliance with the specifications and/or each and every specified test, including commissioning tests, manufacturer shall submit to the purchaser six signed copies of a report covering such tests.
- 7.25.1.5 Test reports shall indicate the tests performed, the results obtained, instruments used, names of test personnel and provisions for witnesses signature. They shall also be numbered and dated. Format of these reports shall be submitted alongwith testing procedure for the purchaser's approval well in advance.
- 7.25.1.6 The test report shall include, but not necessarily be limited to the following:-
- A description of the test equipment with diagram showing arrangement of the test instruments and devices.
 - Sample computation, where necessary or desire able to show the test values employed in the equations.
 - Curves showing relation of tested quantities.
 - Data in tabulated form.
 - Comparison of the test results with the guarantee requirements of the specification and explanation deviations, if any.
- 7.25.2 **SHOP TESTS**
- 7.25.2.1 All major parts of the equipment, necessitating subdivision for transport and subsequent reassembly at site, shall be match assembled in the factory and carefully match marked before dismantling. At all stages of assembly where accuracy of fitting has to be assured at site, dowel holes shall be provided with dowels to assist in reassembly.
- 7.25.2.2 The switchgear shall be completely assembled in the factory in sub assemblies of max. size and then each sub assembly shall be shop tested. Additionally 3-phase transmission line switchgear bay module shall be completely assembled including a representative section of outdoor SF6 gas insulated bus duct and one outdoor SF6/air bushing. All control and terminal boxes shall be temporarily connected with all power supply, control, interlocking and alarm wiring and piping such that the complete switchgear module may be tested in the shop before shipment as specified below.
- 7.25.2.3 Switchgear Component forming part of G.I.S. namely circuit breaker, disconnector, grounding switches, Current Transformers, Potential Transformers, Relays, surge arrestors and SF6 bushing which have routine

test covered under other relevant IEC standards and which do not form the part of tests specified below shall have those test performed before being assembled into the switchgear assembled state. However, for electronic modules, equipment and individual components burn-in tests, temperature and voltage stress tests shall also be performed. Routine testing shall be conducted by automatic processes, wherever practical, in particular wiring testing. An example of the other tests referred to above would be as follows:-

- a) Verification of terminal markings and accuracy and composite error tests for current and potential transformers.
- b) Routine and standard acceptance tests for surge arrestors specified in IEC 99-1 and relevant to ZnO type arrestors.
- c) ROUTINE TESTS (On sub-assembly of max.size)
 - i) Power frequency voltage withstand dry tests on the main circuit.
 - ii) Dielectric tests on auxiliary and control circuit.
 - iii) Measurement of the resistance of the main circuit;
 - iv) Partial Discharge measurement.
 - v) Pressure test on enclosures.
 - vi) Gas tightness test
 - vii) Mechanical operation tests.
 - viii) Tests of auxiliary, electrical, pneumatic and hydraulic devices.
 - ix) Verification of correct wiring.

The applicable standards for the above tests shall be IEC 517 and IEC 694.

When switchgear and controlgear are not completely assembled before transport, separate tests shall be made on all transport units. In this event, the manufacturer shall demonstrate the validity of his test (example: leakage rate, test voltage, resistance of part of the main circuit).

In addition, corrosion protection tests at random on all equipment shall be performed.

7.25.2.4 **Mechanical Tests**

Mechanical tests shall be carried out as per respective IEC and also include the following:-

- a) Mechanical Operation – Circuit Breaker:
 - i) 25 open and close at rated voltage and rated pressure.
 - ii) 5 open and close at minimum voltage and minimum pressure.
 - iii) 5 open and close at maximum voltage and maximum pressure.
 - iv) 5 close/open cycles at rated voltage and rated pressure.
 - v) 5 open/close/open cycles at rated voltage and rated pressure.
 - vi) 5 open-close sequences 0-0.3 sec-CO-3 min-CO for line breakers.
 - vii) 5 open-close sequences 0-0.3 sec-CO-3 min-CO for generator Transformers and bus coupler breakers.

- b) The Operating Times Are To Be Recorded As Follows:
 - i) Opening time measured at rated supply voltage for each pole.
 - ii) Closing time measured at rated supply voltage for each pole.
 - iii) Measured mechanical mechanism reset time or hydraulic mechanism recharging time after one opening and one closing.
- c) Mechanical Operation – Isolators and Ground Switches.
 - i) 5 open/close cycles at rated voltage.
 - ii) 5 open/close cycles at minimum voltage.
 - iii) 5 open/close cycles at maximum voltage.
 - iv) Ensure operation of interlocks.
- d) Gas Tightness Leak Test, On Complete Assembly.
- e) Design & visual checks as per respective IEC.

7.25.2.5 **Electrical Tests:**

Electrical tests shall be as per respective IEC's & shall include the following:
The Electrical tests to be performed on the specified factory assemblies shall be as follows:-

- a) Main circuit resistance measurement, each pole.
- b) Measure resistance of circuit breaker close and trip coils.
- c) Measure power consumption of motor operated mechanisms at rated supply voltage.
- d) Ensure operation of electrical interlocks is performed in proper sequence.
- e) **Control Cubicle**
 - i) Operation or functional check of all circuits at rated supply voltage.
 - ii) Dielectric test, of auxiliary circuits at 2000 V 50 Hz for 1 minute.
 - iii) Operation test of all pressure density monitoring switches.
 - iv) Power frequency withstand test.
 - v) Partial discharge test.
- f) **Current transformers (As per IEC 185)**
 - i) Verification of terminal marking.
 - ii) Power frequency tests between sections of Primary and secondary windings.
 - iii) Test of inter turn insulation.
 - iv) Test for composite error.
 - v) Test for accuracy.
 - vi) Partial discharge tests as per IS: 11322.

Following tests shall be carried out for current transformers used for protection purpose.

- i) Knee point voltage test.

- ii) Exciting current test.
- iii) Secondary winding resistance tests.
- iv) Turns ratio test.

g) **Surge arrester (As per IEC 99-4)**

- i) Measurement of reference voltage.
- ii) Residual voltage test.
- iii) Satisfactory absence from partial discharges & contact noise to be checked on each unit by any sensitive method adopted by manufacturer.
- iv) A leakage check may be made on each unit by any sensitive method adopted by manufacturer in case of arrester unit with sealed housing.
- v) Current distribution test for multi-column arrester.

h) **Disconnecter & grounding switch (As per IEC)**

Following tests as per IEC-129:

- i) Power frequency voltage withstand dry tests of main circuit and auxiliary circuits.
- ii) Voltage withstand tests on auxiliary and control circuits.
- iii) Measurement of the resistance of the main circuit.
- iv) Mechanical operating tests.
- v) Measure power consumption of motor operated mechanism at rated supply voltage.

i) **Voltage transformers (As per IEC 186)**

- i) Verification of terminal marking.
- ii) Power frequency withstand test between sections, primary and secondary windings.
- iii) Test for Accuracy
- iv) Partial discharge test.

7.25.2.6 Any assembly which fails to meet the requirements of these tests shall not be shipped, except on specific approval of the purchaser.

7.25.2.7 In addition to the above tests, all enclosures shall be pressure tested after manufacture in accordance with the latest requirements of IEC 517, Section 31.

7.25.2.8 For bus bars & bus ducts the routine testing shall be as per the relevant IEC standard & shall also include the following:-

BUS BARS

S.No.	Name of the Test	PERCENTAGE CHECK TO BE APPLIED FOR VARIOUS TESTS				
		Support Insulator	Gas barrier	Enclosure	Conductor	Accessories
1.	2.	3.	4.	5.	6.	7.

i) Dimension	100%	100%	100%	100%	100%
ii) Gas Tightness	-	100%	100%	-	100%
iii) Pressure Test	-	100%	20%	-	-
iv) Welding (X-ray)	-	-	5%	-	-
v) Electric resistance	-	-	-	100%	-
vi) 50 Hz voltage withstand	100%	100%	-	-	-
vii) Partial discharges	100%	100%	-	-	-
viii) Section shall be RIV free at 2 times rms line to ground.	100%	100%	100%	100%	-
ix) Weld shall be leak tested with SF6 leak detector.	-	-	100%	-	-
x) Contact resistance at plug in contact.	-	-	-	100%	-
xi) Cleanliness aspect	100%	100%	100%	100%	100%
xii) Silvering	-	-	-	*	-
xiii) Packing	*	*	*	*	*

* : Sample tests or control

- : Not required.

7.25.2.9 TESTS TO MEASURE LOSSES IN BUS CONDUCTOR AND ENCLOSURE OF THE BUS DUCTS

Tests at factory and at site shall be carried out by the supplier to prove that actual measured losses during testing are within guaranteed values quoted in the tender. Tenderer shall furnish methodology of carrying out loss measurement in his tender. If after deduction of tolerance as specified by the tenderer, the actual losses during testing exceed the guaranteed value of losses up to a maximum limit of 5%. The supplier shall pay to the purchaser as penalties @ Rs. 2,80,000 per K.W. as specified in clause 7.14.16.

If the measured losses exceed by more than 5%, supplier can make necessary modifications to prove the losses to be within limits by retesting, without any extra cost to the purchaser. However should the losses exceed the specified limit of 5% purchaser reserves the right to reject the bus duct.

7.25.3 TYPE TESTS

7.25.3.1 The following type tests shall be made on a complete single pole assembly of one typical switchgear bay module as per IEC 517 and IEC 694. Components forming parts of the GIS which are covered by other standards shall comply with and shall be type tested according to those standards.

For all type of relays, complete type test certificates and data sheets must be submitted. If provided and conducted tests would not be to the satisfaction of the Inspection Engineer, the performance which are missing shall be performed by the Contractor at the Contractor's expenses.

The tenderer shall furnish design test certification to demonstrate that the CGI bus ducts has been type tested according to latest applicable IEC standards.

7.25.3.2 Should a similar switchgear bay module have been previously subjected to all of the type tests stated below, certified type test reports may be accepted in lieu of a repetition of such tests at purchaser's option:-

- a) Tests to prove the ability of the main and earthing circuit to carry the rated peak and the rated short time withstand current.
- b) Tests to prove strength of enclosures.
- c) Tests to verify the protection of persons against contact with live and moving parts.
- d) Lightning impulse voltage dry tests.
- e) Switching impulse voltage dry tests.
- f) Power frequency voltage dry tests
- g) Thermal stability test.
- h) Partial discharge tests.
- i) Radio interference voltage tests.
- j) Temperature rise tests.
- k) Tests to verify the resistance of the main circuits.
- l) Short-time current tests on main circuits.
- m) Short-time current tests on grounding circuits.
- n) Verification of making and breaking capacities.
- o) Internal arc tests.
- p) Mechanical operation tests.
- q) Operation tests at limit temperatures.
- r) Verification of degree of protection of auxiliary and control circuits.
- s) Earthquake withstand test.

7.25.3.3 In addition, the following type tests on one piece each of related component parts of a single pole assembly of one typical switchgear bay module shall be made.

a) Circuit Breakers (In Accordance With IEC 56-4)

- i) Tests to prove performance when breaking line charging currents.
- ii) Tests to prove performance when breaking single capacitor bank currents.
- iii) Tests to prove performance when breaking small inductive currents.
- iv) Dielectric test.
- v) Radio Interference Voltage tests.
- vi) Temperature rise tests.
- vii) Measurement of Resistance of main circuit.
- viii) Short time withstand current and peak withstand current tests.
- ix) Mechanical and environmental.
- x) Short circuit test quantities.
- xi) Short circuit test procedures.

b) Surge Arrestors (In Accordance With IEC 99-1)

- i) Power frequency voltage spark over tests.
- ii) Voltage impulse sparkover tests.
- iii) Residual voltage tests.
- iv) Current impulse withstand tests.

- v) Operating duty test.
- vi) Pressure relief tests.
- vii) Partial Discharge test.

c) SF6-To-Air Bushings (In Accordance With IEC 137)

- i) Power frequency withstand test across open contacts for one minute .
- ii) Radio interference voltage tests.

d) Isolators & Earth Switches (In Accordance With IEC 129)

- i) Arcing test across open contacts for 1 min.
- ii) Out-of-phase switching test.
- iii) Dielectric test.
- iv) Radio Interference Voltage (r.i.v) tests.
- v) Temperature rise tests.
- vi) Measurement of the resistance of the main circuit (for disconnectors).
- vii) Short time and peak withstand current tests.
- viii) Tests to prove the short circuit making performance of earthing switches.
- ix) Operating and mechanical endurance tests.
- x) Operation at the temperature limits.

e) CTs (As per IEC 185)

- i) Verification of terminal marking & polarity.
- ii) Power frequency dry withstand tests on primary windings
- iii) Power frequency dry withstand tests on secondary windings
- iv) Over voltage inter-turn test
- v) Determination of errors or other characteristics.
- vi) Short time current tests.
- vii) Temperature rise test.
- viii) Lightning impulse withstand test.
- ix) Switching impulse voltage withstand test.
- x) Determination of error or other characteristics.

f) Potential Transformers (As per IEC 186)

- i) Verification of terminal marking.and polarity
- ii) Power frequency dry withstand tests on primary and secondary windings.
- iii) Determination of errors or other characteristics
- iv) Lightning impulse withstand test.
- v) Switching impulse withstand test.
- vi) Determination of errors.

7.25.3.4 Pressure Vessel Test

Test according to used pressure vessel code shall be performed on the enclosures.

7.25.4 **SHOP TEST REPORTS**

Manufacturer shall furnish to the purchaser six bound certified copies of a report describing the complete shop tests. This report shall include, but not necessarily be limited to, the following:-

- a) A description of the test equipment with diagram showing arrangement of the test instruments and devices.
- b) Sample computation, where necessary or desirable, to show the test values employed in the equations.
- c) Curves showing relation of tested quantities.
- d) Data in tabulated form.
- e) Comparison of the test results with the guarantee requirements of the specifications and explanation of deviations, if any.

7.25.5 **PERFORMANCE TESTS**

7.25.5.1 Performance tests will be required to prove that equipment meets the requirements of the specifications and the guarantees. All tests shall be conducted by Manufacturer subject to purchaser's approval. Manufacturer shall supply all labour, consumables, material, equipment, meters, gauges and the like necessary for the performance of all tests and recording the results of the tests and assume full responsibility for the operation and safety of the equipment during all tests. Manufacturer shall prepare reports of all tests and these reports shall be incorporated in the final test report. The performance tests shall comprises of:-

- a) Field stage tests, to be carried out during erection, to demonstrate that the equipment or any component or sub-assembly has been properly erected and the same functions correctly.
- b) Commissioning tests, precedent to the Acceptance of work, in respect of the equipment or any section of the equipment, to demonstrate its proper operation.
- c) Final acceptance tests, precedent to issue of a Final Acceptance Certificate, to prove compliance with performance guarantees.

7.25.5.2 **Field Stage Tests**

From time to time at various stages of erection, tests of sub-assemblies of the equipment shall be carried out as instructed by the purchaser. The Manufacturer shall make records of all measurements and shall make corrections or adjustments as required. A record of all stage tests shall be embodied in a report. These tests shall include, but not be limited to, the following:-

- a) Continuous testing of the properties of SF6 gas through the entire filling period.

- b) Testing of all current carrying and ground connections to all conductors and terminal pad, to determine that full clamping pressure is applied to all contact surfaces and all bolted connections are tightly secured with lock washers; testing of all flexible connections to ensure that sufficient slack is available for expansion.
- c) Individual inspection of pressure relief devices, density/pressure gauges and all other auxiliary devices to determine their conditions.
- d) Check of cabling between apparatus by the Contractor, prior to acceptance tests. Random checks shall be made in the presence of the Engineer.
- e) Measurement of the insulation resistance to earth of the various measuring and control circuits. Including cables, instruments and apparatus wherever practical and feasible.
- f) Check of all relay settings shall be in accordance with the calculated values and afterwards primary inspection tests by introducing fault artificially wherever feasible, otherwise testing with testing apparatus (simulated method). Primary checking of all tripping circuits.
- g) Operating checks of all control, signaling, measurement, metering, recording and interlocking equipment to confirm complete conformity with designed data.

Prior to commencement of these tests, the contractor shall submit a detailed programme to the Engineer for approval. Detailed records, including all details of tests performed and results obtained shall be prepared by the Contractor.

7.25.5.3 Commissioning Tests

1. On completion of the erection and installation to its satisfaction, the Manufacturer shall give the purchaser a written certificate stating that the equipment has been erected and installed in accordance with the specifications and approved drawings, thus giving notice of readiness to carry out the commissioning tests. The tests, which shall be carried out before the equipment is placed into regular service, shall demonstrate that all guarantees have been met by Manufacturer and, in addition, the entire equipment, including all auxiliary equipment and accessories, are properly erected, installed and correctly adjusted.
2. The following commissioning tests shall be performed as agreed between Manufacturer and purchaser and as per IEC 517.
 - a) "High voltage tests for the main circuit and GI bus ducts for one minute power frequency withstand voltage". If any special arrangement is required for performance of this test, the manufacturer shall make such suitable arrangements accordingly.
 - b) Voltage tests for the auxiliary and control circuits.
 - c) Tests to verify the resistance of the main circuits.

- d) Operation tests for various components.
 - e) Gas leakage tests.
 - f) Calibration of SF6 gas pressure/density switches.
 - g) Measurement of moisture.
 - h) Evacuation & vacuum risk leak test of all flange connections for GI bus ducts.
 - i) Partial discharge measurement test.
- .3 After erection, a test shall be made to prove the absence of dangerous voltages in the enclosure and other metal parts such as pipes and framework
- .4 Should be tests prove the existence of any fault or faults in the equipment, or any failure to meet the requirements of the specifications, the purchaser may direct Manufacturer to remedy the defect(s) or repair, reconstruct or replace faulty work and Manufacturer shall, without delay, carry out the instructions of the purchaser in this respect.
- .5 Except as otherwise provided hereunder, responsibility for apparatus and test equipment and the control thereof shall be exercised by Manufacturer subject to the overriding control of the purchaser.
- .6 Commissioning tests shall be as per the standard IEC & shall not be restricted to the one stated above. Also, tenderer shall recommend any additional commissioning tests.

7.25.5.4 **Final Acceptance tests**

After commissioning tests have been satisfactorily completed, Manufacturer, in cooperation with and under the supervision of purchaser shall conduct the final acceptance tests scheduled below to determine whether all Manufacturer's guarantees and requirements of these specifications have been fulfilled.

- a) SF6 GIS, complete with all appurtenances, shall be operated at continuous rating, and at such part loading as may be directed by the purchaser, continuously for 30 calendar days.
- b) All shop tests included in the test report specified in Clause 7.25.2 shall be deemed to be a part of the final acceptance tests. Certain routine tests may be repeated at the site, if in the opinion of the purchaser, they are necessary to establish the conformity of the equipment with the guarantees and the specifications.
- c) A record of all performance Tests shall be embodied in a test report.

Successful completion of the final acceptance tests shall be a condition precedent to final acceptance certificate in respect of the equipment.

7.26 TEST REPORT

Manufacturer shall record all relevant facts and quantities from which he will prepare a final test report. Such report will be prepared in a form approved by the purchaser and reproduced at the expense of Manufacturer in six copies.

7.27 STANDARDS, DRAWING & DESCRIPTIVE DATA

7.27.1 Drawings, documents and data to be furnished along with the tender

The manufacturer shall furnish following documents alongwith the tender

- i. Copies in English of the standards to which the GIS and auxiliaries will conform, if different from those specified, together with written proof of equivalence.
- ii. Drawings including outline drawing and photographs to show the general construction and overall dimensions of the equipment proposed. The drawings shall also show the location and general arrangement of all auxiliary devices and H.V. terminal arrangement. All dimensions shall be in mm.
- iii. Drawings, technical details and operational capabilities of the SF6 gas treatment unit proposed for use with this installation.
- iv. Technical literature/catalogue of the various components used in the assembly.
- v. Description of untanking procedure for circuit breakers and disassembly of other switchgear components, including extent of repairs which will be possible within the switchyard building.
- vi. Details of circuit breaker interrupting chambers and operating mechanisms.
- vii. Details of isolators and grounding switches and associated operating mechanisms.
- viii. Details of current and potential transformer construction, including types of insulation materials used.
- ix. Outline drawing and details of gas-insulated surge arrestors.
- x. Typical bushing drawings.
- xi. Outline drawing and details of SF6/air outdoor bushings to include details of mounting at support structure and arrangement for taking up thermal expansion of bus duct.
- xii. Details of gas pressure/monitoring system and devices.

- xiii. Typical details of terminal and control cubicles.
- xiv. General arrangement, schematics and alarm annunciation scheme drawings.
- xv. Detailed procedures for dismantling of bus bars and other equipment.
- xvi. Details of annunciation system proposed, including typical schematic or wiring diagram.
- xvii. Typical details of electrical and mechanical interlocking system proposed.
- xviii. Details of typical support structures.
- xix. Typical wall entrance place assembly.
- xx. Tables listing material specifications for various equipment components.
- xxi. Painting systems, cleaning and application procedures.
- xxii. Listing of applicable pressure vessel codes to which the pressurized enclosures conform.
- xxiii. Drawing showing outline and drilling details for each type of relays and also for all loose equipments such as stabilizing resistors, non-linear resistors etc.
- xxiv. Diagrams of interconnection between modules for each type of relay.
- xxv. Where applicable, a drawing showing the interconnection between the associated relays in a scheme of protection complete with all necessary polarity markings on relays, current transformers and voltage transformers.
- xxvi. If protection includes items which shall be separately mounted, then an outline mounting and wiring diagrams shall be included.
- xxvii. Beside copies of all drawings (following approval), one reproducible transparency of every drawing shall be supplied.
- xxviii. Description & diagram of the proposed grounding system.
- xxix. Insulation coordination study.

7.27.2 Drawings, documents and data to be furnished after the award of contract

- i) Layout drawing of GIS hall showing SF6 Gas Insulated Switchgear and control gear.
- ii) Drawing showing the constructional features and dimensions of various equipment.

- iii) Equipment general arrangement drawing showing plan, transverse and longitudinal sections, openings in floors for equipment handling, foundation details, embedment etc. along with supporting calculation for foundation loads etc.
- iv) Key-diagrams, schematic diagrams of all controls, protections and alarm system. Wiring diagrams for all electrical circuits cabling layout etc.
- v) Foundation drawings of all components / parts of the plant showing the details of the foundation required for GIS equipment and all ducts, trenches etc. required for pipes, cables and other accessories. These drawings shall contain all the information required by the purchaser for designing the civil works.
- vi) Detailed drawings of the entire equipment which shall include separate drawings of all important components/ parts of the plant clearly showing details like mode of fastening etc. The drawings shall be sufficient to furnish a complete understanding of the design & working of the entire equipment and shall contain necessary information required for erection and maintenance.
- vii) Records of all shop testing and inspection of materials, components sub-assemblies, equipment, machinery etc.
- viii) Instruction for storage, preservation & handling of equipment.
- ix) Erection / installation sequence and procedures.
- x) Testing procedures.
- xi) The drawing, data and information shall be elaborated enough to enable the purchaser to comprehend and assess the vital details, features, capabilities functioning of the equipment and their arrangement.
- xii) Calculation for selection of bus bar conductor, its efficacy to system short circuit and temperature rise.
- xiii) Any other drawing, literature, documents not specifically listed but considered essential.

7.28 INSTALLATION, OPERATION AND MAINTENANCE MANUALS

7.28.1 For guidance during installation of the work and subsequently for guidance of the plant operating and maintenance staff, manufacturer shall prepare manuals containing the following:-

a) Handling Section

This shall contain detailed information as to the system of marking adopted to show slinging points, points of support, restrictions as to position of transport of any package and position of application of any

cradles provided for use during transport, or site storage of any item, restrictive instructions, and the form in which such instruction is inscribed in the package; a full list of special slings, spreaders, cradles and the like which have been provided and the purpose of each; and full directions as to the conditions of site storage to be observed

b) Erection Section

This shall include full and detailed instructions, procedures and precautions to be observed in erecting, assembling, gas processing and initial filling procedures, adjusting the equipment and the use of the erection equipment. It shall include or be accompanied by drawings showing erection marking and match marking and shall embody a full statement as to erection tolerances to be observed.

c) Site Testing Section

This shall include full detailed directions as to the methods and procedures to be followed and the quantities to be observed and recorded in checking the accuracy of erection, and carrying out of site tests as required by the specifications. It shall also include a description of all equipment and instruments provided for these tests and of their use.

d) Operation and Maintenance Section

This shall include complete instructions for the operation and maintenance of the equipment, not only during the period of the Manufacturer's liability but more particularly during its operating life. The directions shall be set out simply, clearly and systematically. In particular, this volume shall include a full list of all routine checks and their timings, directions as to fault findings, details of all routine attentions (such as lubrication, etc.) and recommendations as to the observations which should be recorded.

- 7.28.2 Eleven (11) copies of the manuals shall be submitted in draft form for review and comment by purchaser 4 months prior to the time the information is required at site. Thirteen (13) suitably bound copies shall be provided to purchaser not later than 30 days after final review by the purchaser.
- 7.28.3 If revision of the manuals becomes necessary, as a result of information gained during installation and initial operation, the Manufacturer shall make the necessary revisions and furnish thirteen (13) copies of the revised sections at no additional cost to purchaser.
- 7.28.4 The manuals shall include a complete list of all drawings prepared by Manufacturer, a list of spare parts for each component or item of equipment. The parts list shall also include Manufacturer's name and serial numbers.
- 7.28.5 Manufacturer shall ensure that its installation supervisor has a copy of all final drawings and manuals in his site office.
- 7.28.6 The manuals shall include catalogue, data sheets for every single piece of equipment installed in the switchgear.

7.29 ERECTION, TESTING EQUIPMENT AND MAINTENANCE TOOLS

Manufacturer shall provide all erection equipment for the installation, testing and initial operation of the work. In addition, Manufacturer shall furnish equipment, wrenches and tools in new and unused condition to be used only for the maintenance of the work during its useful life. All tools, instruments and equipment either imported or locally procured shall be new and shall become and remain the property of the purchaser. Erection and testing equipment and maintenance tools shall include, but not be limited to the following:-

Any special tools required for installation and removal of the 420 kV circuit breaker interrupting heads, isolating switches, grounding switches, bus duct etc.

For lifting of large subassemblies, manufacturer shall provide all necessary spreader beams, slings and tackles, suitable for use with the switchyard building overhead crane.

Hand tools including but not limited to the following:-

Two sets of single end spanners to fit every type and size of nut or bolt head in the plant and erection equipment;

Two sets of screw drivers, pliers, and other normal hand tools;

Two sets of any special hand tools necessary as per design of the plant.

Complete sets of case-hardened wrenches and special wrenches, tools, pulling eyes and other equipment that may be required or convenient for the most expeditious erection, assembling, dismantling and maintenance of any part of the plant and accessory equipment. Wrenches and tools for maintenance, in so far as practicable, shall be mounted on suitable hardwood or steel boards arranged for wall mounting and provided with means for ready identification.

The equipment and instruments required for testing as specified under commissioning and final acceptance tests.

7.30 SCHEDULE OF REQUIREMENTS

7.30.1 a) Double bus bar system - GIS

Two Nos. 3 phase, SF6 gas insulated, metal-enclosed 4000 A bus bars enclosed in three individual bus bar enclosures running along the length of the switchgear to interconnect each of the circuit breaker bay modules and each bus bar comprising of:

- i) 1-Three phase high speed fault making grounding switch complete with group operated manual and motor driven operating mechanism.

- ii) 3 –Single phase voltage transformers with three secondary windings alongwith one three phase group operated disconnector complete with motor driven operating mechanism.
- iii) 3-Single phase 336 kV (r.m.s.) SF6 Surge Arrestors.
- iv) 1-Three phase group operated safety grounding switch complete with manual and motor driven operating mechanism (between bus bar and VT feeder)
- v) 1-Local control panel.
- vi) Lot: SF6 gas monitoring for the complete bay.

Note:- The manufacturer shall perform an insulation co-ordination study to verify protection of switchgear and main transformers against over voltages is adequate. The final surge arrester characteristic, their number and exact locations of surge arrestors shall be decided after this study.

b) Bus coupler Bay

One, 420 kV, bus coupler circuit breaker bay module comprising:-

- i) One 4000A, 3 phase, SF6 gas insulated circuit breaker complete with common and reliable operating mechanism for all three phases.
- ii) Six, triple core, 4000-2000-1000/1A single phase current transformers.
- iii) Two three phase, 4000A group operated isolator switches, complete with manual & motor driven operating mechanisms.
- iv) Two three phase, group-operated safety grounding switches, complete with motor driven operating mechanism.
- v) 1 local control panel.
- vi) Lot: SF6 gas monitoring system for the complete bay.

c) 6 Generator Transformers feeder bays:

Six – 420 kV generator transformer feeder circuit breaker bay modules each comprising:-

- i) One – 800 A, three phase, SF6 gas insulated circuit breaker, complete with common and reliable operating mechanism for all three phases.
- ii) Three- 5 core, 150/1 A single phase current transformers.
- iii) Three – 2 core, 4000-2000-1000/1A single phase current transformers.
- iv) Three- 1 core, 150/1 A single phase current transformers.

- v) Two-three phase, group operated bus bar disconnectors, each complete with manual and motor driven operating mechanisms.
- vi) One-three phase, group operated, safety grounding switch, each complete with manual and motor driven operating mechanism.
- vii) One-three phase high speed fault making grounding switch, complete with group operated manual and motor driven operating mechanisms.
- viii) Three-336 kV single phase, SF6 insulated, metal enclosed zinc oxide surge arrestors.
- ix) Three-Single phase gas insulated terminal connections connecting Generator Transformer (Oil/SF6) bushings with GIS through gas insulated bus ducts (800 Amp rating).
- x) One-local control panel.
- xi) Lot: SF6 gas monitoring system for the complete bay.

d) Line feeder bays. (GIS Indoor)

Four-420 kV, 2000A transmission line feeder circuit breaker bay modules, each comprising:-

- i) One –2000A, 3 phase, SF6 gas insulated circuit breaker with pre-insertion resistors complete with separate and reliable operating mechanisms for each phase.
- ii) Three – 3 core single phase current transformers (2000-1000/1A).
- iii) Three – 2 core, single phase current transformers (4000-2000-1000/1A).
- iv) Two – 3 phase, 2000A, group operated bus bar disconnector, each complete with manual and motor driven operating mechanisms.
- v) One-three phase, 2000A group operated feeder disconnector, complete with manual and motor driven operating mechanisms.
- vi) Two-3 phase group-operated safety grounding switches, each complete with manual and motor driven operating mechanisms.
- vii) One-3 pole, high speed fault making grounding switch, complete with group-operated manual and motor driven operating mechanism.
- viii) Three-single phase, SF6 gas insulated metal enclosed bus ducts to outdoor SF6/Air bushings (as per the layout drawing) complete with support structures and other accessories.
- ix) Three- single phase, SF6/air outdoor bushings complete with mounting structures, terminal connectors and other accessories.
- x) Three-336 kV single phase, SF6 insulated, metal enclosed zinc oxide lightning arrestors.
- xi) One-local control panel.
- xii) Lot: SF6 gas monitoring system for the complete bay.

Each module (a) to (d) shall be complete with all necessary terminal boxes, control cabinet, interconnecting power and control wiring, grounding, gas monitoring equipment and piping, support structures and platforms etc.

- e) Lot:
 - (i) Control Cables for connection between local control panels and various equipment in the switchgear bay.
 - (ii) Control cables between local control panels to different RTUs for remote indications and controls.
 - (iii) Control cables required for electrical inter-locking etc.
- f) Lot : Power cables for connection between local control panels and various equipments (like motor etc.) in the switchgear bay.
- g) SF6 gas for first filling in returnable (or non-returnable) steel bottles/cylinders.
- h) Galvanised steel structures for mounting the switchgear including all fittings etc.
- i) Complete material fitting etc. required for the grounding of GIS.

7.30.2 THE SCOPE OF SUPPLY SHALL ALSO INCLUDE

- a) First filling of SF6 gas for the equipment supplied plus an additional quantity sufficient for conducting all tests on equipment at site before placing it into successful operation. Additionally, 10 percent of total quantity of SF6 gas shall also be supplied in non-returnable cylinders.
- b) One gas processing unit suitable for evacuating, liquefying, filling, drying and purifying SF6 gas during initial installation, subsequent maintenance and future extension of the GIS.
- c) One set of switchgear handling equipment and any special tool required for handling and dismantling of the switchgear and auxiliary equipment.
- d) All equipment, instruments and devices necessary for maintenance of the switchgear and auxiliary equipment.
- e) All materials, consumables, tools, devices, testing equipment and instruments necessary for complete installation, testing, commissioning and placing into successful operation of the equipment.
- f)
 - i) Complete installation, testing, commissioning and placing into successful operation of the equipment.
 - ii) One set of applicable standards.

g) Spare Parts (Mandatory)

The tenderer shall quote for the supply of the following spares indicating their itemized unit prices. The tenderer shall also submit with his proposal a recommended list of spares for complete GIS equipment required for its initial 5 years of normal operation in the form of Annexure. The purchaser reserves the right to purchase any or all of the spare parts listed below or recommended by manufacturer:-

- i) 2 Nos. SF6 /Air outdoor bushings, complete with gaskets and connectors.
- ii) 1 No. 420 kV 2000A circuit breaker interrupting heads, complete with all necessary apparatus.
- iii) 1 No. 420 kV, 800 A circuit breaker interrupting heads complete with all necessary apparatus.

- iv) 1 No. 420 kV, 4000A circuit breaker interrupting heads, complete with all necessary apparatus.
- v) 1 No. 420 kV, 2000 A circuit breaker operating mechanisms, complete with all necessary connecting apparatus.
- vi) 1 No. 420 kV, 800 A circuit breaker operating mechanisms, complete with all necessary connecting apparatus.
- vii) One set each of 420 kV, 2000A isolator switch internal parts, complete with all necessary gaskets, mounting hardware etc.
- viii) One set each of 420 kV, 2000 A isolator switch operating mechanism.
- ix) One set each of 420 kV, 800 A isolator switch operating mechanism.
- x) One set each of 420 kV, 800 A isolator switch internal parts, complete with all necessary gaskets, mounting hardware etc.
- xi) One set each of 420 kV, 4000 A isolator switch internal parts, complete with all necessary gaskets, mounting hardware etc.
- xii) One set each of 420 kV, 4000A isolator switch operating mechanism, complete with all necessary connecting apparatus.
- xiii) One set of 420 kV safety grounding switch internal parts complete with all necessary gaskets, mounting hardware etc.
- xiv) One 420 kV, safety grounding switch operating mechanism, complete with all necessary connecting apparatus.
- xv) One, $\frac{420 \text{ kV}}{\sqrt{3}}$ / $\frac{110 \text{ V}}{\sqrt{3}}$ / $\frac{110 \text{ V}}{\sqrt{3}}$ / $\frac{110 \text{ V}}{\sqrt{3}}$ VT core, complete with all gaskets, mounting hardware etc.
- xvi) One set of 400 kV current transformer cores, set to comprise one core of each ratio, burden and accuracy used in the equipment.
- xvii) Two, 336 kV, single phase, station class gas insulated gap less surge arrestors.
- xviii) Three, gas monitoring devices complete with all necessary fittings, gaskets & switches.
- xix) One set of control switches/control relays comprising one switch / relay of each type and rating used in the control cubicles.
- xx) One set of low voltage circuit breakers, comprising one circuit breaker of each type and rating used in the control equipment.
- xxi) Ten sets of control circuit fuses, each set to comprise one of each type and rating of control circuit fuse used on the equipment.
- xxii) Ten sets of LEDs, each set to comprise one of each type and rating used on the equipment.
- xxiii) Three sets of inspection windows.
- xxiv) Hundred sets of sheer pins.
- xxv) Hundred 420 kV circuit breaker closing coils.
- xxvi) Two Hundred 420 kV circuit breaker trip coils.
- xxvii) One set of spare parts for SF6 gas processing unit.
- xxviii) 20% of cards, contactors and auxiliary relays of each type in local control cubicles.
- xxix) Set of spare auxiliary contacts for isolator switches and grounding switches.
- xxx) One set of 420 kV high speed fault making switch internal parts complete with all necessary gaskets, mounting hardware etc.

- xxxi) One set of 420 kV high speed fault making grounding switch internal operating mechanism complete with all necessary connecting equipment.

7.31 GUARANTEED TECHNICAL PARTICULARS

Guaranteed technical particulars as called for in “Annexure-II” shall be furnished alongwith the tender. In the absence of requisite data, it may not be possible to evaluate the suitability and adequacy of the equipment. Particulars subject to guarantee shall be clearly marked.

7.32 SCHEDULE OF INSTALLATION

The tenderer shall furnish a list of similar equipments supplied and duly erected by him as per performa given in Annexure-VIII.

7.33 DEVIATION FROM SPECIFICATION

All deviations from the specification shall be separately listed in Annexure-IV in the absence of which it will be presumed that the provision of the specification are fully complied with by the tenderer.

7.34 COMPLETENESS OF THE CONTRACT

Any fittings, accessories or apparatus which may not have been specifically mentioned in these specifications but which are usually necessary in the equipment of similar plant shall be deemed to be included in the contract and shall be supplied by the Contractor without extra charges. All plants and equipment shall be complete in the details whether such details are mentioned in the specification or not.

7.35 ANNEXURES TO BE FILLED BY BIDDERS

7.35.1 The annexures are annexed with this section herewith for bidders to fill them & furnish in their bids. The annexures shall be comprehensively, exhaustively & meticulously filled without any changes.

7.35.2 The bidders shall also furnish any additional information essential for evaluation of their bids over and above the annexures.

7.35.3 Non compliance with the above will lead to rejection of bids.

7.36 SPARES (Recommended)

The tenders shall quote, but separately in Annexure-VI, for all the recommended spares sufficient for first five years of the normal operation for 420 kV SF6 Gas Insulated Switchgear in their tender, listing items, their particulars, make, unit rate and total price etc. The spare part shall be interchangeable with and shall be of same or higher quality than the original component.

7.37 SPECIAL TOOLS, TACKLES & SLINGS

Complete out fit of tools, special tools, spanners, gauges, slings and other lifting devices, instruments and appliances necessary for the complete assembly, erection at site, dismantling and maintenance of the GIS & CGI bus duct, including all accessories covered by the contract together with suitable racks for holding them shall be supplied by the contractor.

The spanners shall be single ended and made to fit each size of nut and bolt of the GIS as stated above. One set of spanners tools, appliances and special tools shall be supplied.

The bidder shall propose, design and provide the handling equipment for the erection and future maintenance of SF6/Air bushing outside the GIS Building. For which bidder has to take prior approval from the purchaser.

7.38 CONSUMABLES

The tender shall include and quote for all consumables that shall be required for the site assembly, erection, testing & commissioning of the 420 kV Gas Insulated Switchgear. A complete list of the items of consumables and their quantities shall be furnished in the tenders alongwith the rate and total prices. SF6 Gas for 420 kV GIS (with 10% extra) shall be included in the quoted prices of the equipment.

Any additional requirement shall be the responsibility of the supplier and no extra prices shall be payable for the same.

7.39 TESTING INSTRUMENTS & DEVICES

The tenderer shall quote for testing devices, instruments etc. required during assembly, erection, testing and commissioning & during service of 420 kV SF6 GIS. A complete list of the items shall be furnished in the tender with technical details, quantities, itemized rated and prices. Any additional requirement shall be the responsibility of the supplier and no extra price shall be payable for the same at later stage.

The supplier of the GIS shall arrange for all testing devices and instruments required for the final acceptance tests. Non-consumable items can be taken back by vendor after completion. A complete list of such items shall be furnished in the tender with their technical details, quantities etc.

7.40 DEPUTATION OF ENGINEERS FOR WITNESSING TESTS, INSPECTION AND TRAINING

7.40.1 Purchaser will depute engineers for the following purpose:-

- (a) 420kV SF6 Gas Insulated Switchgear
 - i) Inspection of various tests/checks on important component of 420kV SF6 GIS, sub-assemblies and accessories
- 3 Engineers from time to time, total engineer months

- | | |
|--|--|
| during various stage of manufacture from material testing till dispatch. | envisaged six,18 round trips. |
| ii) Training in workshop and design office including visit to important hydro stations. This training shall also cover for operation and maintenance of 420 kV GIS at manufacturer works, design Office and on hydro control station. As a guide line the training should be Designed to accomplish the following Objectives:- | 8 Engineers for a period of six weeks (Total 48 engineer weeks)8 round trips |
| <ul style="list-style-type: none"> - To teach the engineer the principles of system operation and maintenance and give them a firm under standing of all system functions. - To instruct the engineers the way to use various maintenance aids and test equipment for periodical/routine maintenance. - To guide on management system on the basis of running hydro station visits. | |
| iii) In addition an expert from Project's Retainer Consultant may also participate in testing and inspection. | 1 Engineer for a period of one month (one engineer month) 3 round trips |

7.41 QUALITY ASSURANCE PLAN

The following inspections and tests in conformity with the relevant IEC shall be included but not be limited to, in the scope of the Quality Assurance Programme.

1. Material Incoming Inspection.
 2. SF6 Gas Leakage – Gas tightness control,
 3. Mechanical operation of the switchgear
 4. Resistance of the main current path.
 5. Electrical contacts control.
 6. Insulator control.
 7. Secondary winding.
 8. High voltage test:
- a) Dielectric strength – Power frequency voltage test.
 - b) Verification of partial discharge level.
 - c) On site, high voltage test at reduced voltage to detect any possible errors made during erection or damage caused during transportation.

The inspections and tests criteria, the methods assuring the high quality of individual components and sub-assemblies shall be compiled in a manual which is to be submitted in the offer.

The supplier shall submit a detailed quality assurance plan within 30 days after the contract commencement date intimating the testing programme to the purchaser for approval.

ANNEXURE-I

SCHEDULE OF WEIGHTS AND SIZES OF SHIPPING UNITS
(To be filled by the bidder)

S.No.	Description of Shipping Unit	Weight of Each unit	Dimension of each unit
1.	2.	3.	4.
1.	Breaker Pole		
2.	Busbar disconnecter with bus bar		
3.	Disconnecter		
4.	Safety grounding switch		
5.	High speed fault making grounding switch		
6.	CGI bus-duct assembly		
7.	Gas processing unit		
8.	Local control Panels		
9.	SF6 gas cylinder		
10.	Heaviest shipping unit		
11.	Largest shipping unit		
12.	Total tonnage to be shipped.		

NOTE: The description of shipping units mentioned is indicative. The bidder shall furnish information for the shipping units as proposed by him.

Signature of Tenderer

ANNEXURE – II

SCHEDULE OF GUARANTEED TECHNICAL PARTICULARS OF SF6 GAS INSULATED SWITCHGEAR

1. GENERAL

The bidder shall submit with its Tender the following technical particulars for the 420 kV gas-insulated switchgear and accessories, complete with any additional data which, in Bidder's opinion will describe the merits of the equipment offered.

Sl.No.	Description	Unit
1.	Name of manufacturer	
2.	Place of manufacturer, inspection and testing.	
3.	Manufacturer's type designation	
4.	Rated voltage	
5.	System frequency	
6.	Maximum (Continuous) service rated voltage	
7.	Normal Current Rating	
	a) Under normal condition	Amp.
	b) Under fault condition	Amp.
8.	Short Time Current Rating	
	a) 1 sec. rms	KA
	b) 3 sec. rms.	KA
9.	BIL of the SF6 switchgear (KV Peak)	
10.	Switching surge (kV Peak)	
11.	Maximum temperature rise over	oC ambient
12.	Altitude upto which the switchgear shall operate satisfactorily	
13.	Ambient conditions of the operation of the GIS	
14.	Earthing details of enclosure.	
15.	Density and pressure of gas in various compartments of the Enclosure.	

16. Please explain the features adopted for preventing burn through in the various enclosures of SF6 GIS
17. What is the guaranteed life time of the GIS?
18. Guaranteed number of loaded/unloaded operation of various equipment of SF6 GIS i.e. GIS Circuit Breaker, disconnects, earthing switches etc. (Please mention item wise)
19.
 - a) Is the equipment supplied leak proof? If no, the average leakage and percentage per year.
 - b) Quantity of SF6 gas required to completely charge the 3-pole equipment including any tank storage system(kg.)
 - c) Operating pressure, Kg/cm2
20. Detail the feature existing in the equipment to carry out P.D. measurements at works/site.
21. Please state the control wiring features alongwith details of all control wiring used in the equipment.
22. Is it necessary to carryout field welding for site assembly? If yes, please specify the extent of field welding and procedure which the manufacturer proposes to adopt at site.
23. Has an explanation of the basic operating principles of the major components of the equipment, accompanied by drawings, photographs which will present a clear picture of the fundamental principle, general arrangements and operating mechanism been enclosed?
24. Have the flow diagram, showing all valves and pressures involved, on the air and gas system, or both been enclosed?
25. Has test data, which may include parts test data, that indicates ability of the equipment (including high speed grounding switches) been enclosed?
26. If resistors are inserted in the circuit during opening operations, please furnish their values as well as the length of time the resistors are left in the circuit.
27. Methods adopted to limit switching surges for breaker and disconnectors.
28. Values of maximum switching surges generated?
29. Heat generated in K.W. when the complete switch gear is operating at its rated capacity.

30. Please specify the noise level.
31. Material Used In Fabricating (Copper, Aluminium, Silver, etc.)
- a) Breaker main contact surface
 - b) Disconnecting switch contact surfaces.
 - c) Grounding switch contact surfaces.
 - d) Internal bus.
 - e) Internal bus contact surfaces.
 - f) Bus enclosure.
 - g) Terminal pads.
 - h) Terminal pad contact surface
32. **Operating System**
- a) Breaker
 - b) Disconnecting switch
 - c) Quick acting grounding switch
 - d) Slow acting grounding switch
33. Time required to recharge the operating system to a fully charged condition after four successive operations. (without compressor or pump action), minutes:
34. Capacitance per metre of the enclosed bus in pico Farads/metre.
35. Surge impedance in ohms of the enclosed bus (Please describe the methods of calculations used to determine surge impedance and capacitance of insulated bus).
36. Electric Resistance At 30⁰/45⁰C in Ohms/Meter.
- a) Bus enclosure.
 - b) Internal bus.
37. **Dimensions**
- a) Bus enclosure outside diameter (mm)
 - b) Bus enclosure wall thickness (mm)
 - c) Internal bus, outside diameter (mm)
 - d) Internal bus thickness (mm)
38. **Weight**
Please specify the weights of each assembled bay Separately (Kg.)

II. TECHNICAL

Sl.No.	Description	Unit
--------	-------------	------

CIRCUIT BREAKER

1. Name plate data

- | | |
|------------------------------|----|
| - manufacturer | |
| - type designation | |
| - rated frequency | Hz |
| - rated voltage | kV |
| - rated interrupting current | kA |
| - number of poles | |
| - class (Indoors) | |

Breaking Capacity

- i) KA
- ii) MVA (Symmetrical).

Making Capacity
 Make time

2. Operating Voltages

- | | |
|-----------------------------|----|
| - maximum operating voltage | kV |
| - minimum operating voltage | kV |
| - range factor | |

3. Current ratings

- | | |
|---|----------|
| - rated continuous current | A |
| - rated interrupting current for 1s, | kA |
| - rated symmetrical interrupting current | kA |
| - rated asymmetrical interrupting current | kA |
| - percentage D.C. components | |
| - rated making current, | kA(peak) |

4. Rated Insulation level

- a) Dry 1 minute power frequency withstand voltage:

- to earth	kV (rms)
- across open contacts	kV (rms)
- b) 1.2/50 full wave microsecond lightning impulse with stand voltage.
 - i) To ground

- II) Across the open contact
- c) 250/2, 500 microsecond switching impulse withstand voltage kV(peak)
 - d) Line to ground power frequency withstand voltage at gas pressure equivalent to atmospheric pressure. KV
 - e) Minimum external creepage distance phase to ground mm
 - f) Minimum allowable moisture content in interrupting medium ppm
 - g) Total Break time ms
 - i) At 10% rated interrupting capacity ms
 - ii) At 60% rated interrupting capacity ms
 - iii) At rated interrupting capacity ms
5. Maximum temperature rise above ambient at rated load and voltage:
- Contacts oC
 - Hottest part oC
6. Operating data
- rated duty cycle
 - reclosing duty cycle
 - permissible tripping delay ms
 - maximum arc duration at 10% rated breaking current ms
 - 30% -do- ms
 - 60% -do- ms
 - 100% -do- ms
 - Closing time ms
 - Total Break Time ms
 - a) 10% rated breaking current ms
 - b) 30% rated breaking current ms
 - c) 60% rated breaking current ms
 - d) 100% rated breaking current ms
 - e) Arc duration from separation of arc contact to instant of arc extinction for full rated interrupting capacity ms
 - Length of arc at
 - a) 10% rated breaking current mm
 - b) 30% rated breaking current mm
 - c) 60% rated breaking current mm
 - d) 100% rated breaking current mm
 - e) Max. length of arc lowest fault current mm
 - Longest time to interrupt current less than 25 percent of rated symmetrical short circuit current from

Energizing trip circuit.	Ms
- Minimum time from arc extinction to contact remake for auto-reclosing.	
- minimum dead time for;	
a) 3 phase reclosing	
b) 1 phase reclosing	
- maximum difference of time at opening of series contacts within one pole,	ms
- maximum difference of time at opening between phases	ms
- maximum difference of time at closing between phases	ms
- provide a curve of maximum opening as a function of 3 phase fault current.	
- number of interruptions before scheduled maintenance is required.	
- number of mechanical operations before scheduled maintenance is required.	
- number of interruptions at rated S.C. current with associated TRRV without changing any parts.	
- description and frequency of scheduled maintenance required.	
a) recovery voltage - rate of rise at ;	
- rated symmetrical interrupting current	kV/ms
- 60 percent of rated symmetrical interrupting current	kV/ms
- 30 percent of rated symmetrical interrupting current	kV/ms
- 10 percent of rated symmetrical interrupting current	kV/ms
b) Amplitude factor	
c) Phase factor	
d) Natural frequency	(Hz)
- Devices used for controlling	RRRV
- Devices used for uniform voltage distribution	
- Distribution of voltage across breaks.	
- Switching resistors	
- Preinsertion (on closing)	ohm
- Preinsertion time	ms
- Tripping	ohm
Recovery voltage distribution between breaks in percent of rated voltage.	
a) Single line to ground fault	

- b) Interruption of short lines
 - c) Switching off an unloaded transformer
7. Operating mechanism:
- tripping
 - closing
 - number of closing/opening coils to be used.
8. (a) Air supply for mechanical operation (applicable to breakers with pneumatic operating mechanism).
- Compressor motor hp, voltage/phase and quantity of motors
 - Storage air receiver pressure, Kg./cm²
 - Minimum air pressure required for successive interruption At breaker rating Kg/cm².
 - number of stored close-open operations.
 - Quantity of air required for one close-open operation.
- (b) Hydraulic fluid supply for mechanical operation (applicable to breakers with hydraulic operating mechanism)
- pump, motor, hp, voltage/phase and quantity of motors
 - storage compartment pressure, Kg/cm²
 - minimum oil pressure required for successful interruption breaker rating, Kg/cm²
 - No. of stored close-open operation without pumps operation
 - Quantity of oil required for one close open operation
9. SF6 gas system:
- normal operating pressure Kg/Sq.m
 - normal operating density g/cc
 - wt. Of gas per breaker kg
 - lockout pressure kg/sq.m
 - whether breakers work at single pressure or dual pressure
 - type of SF6 gas flow (axial or radial)
 - type of nozzles (single flow or double flow)
 - compression ratio or puffer
 - quantity of compressed gas for puffer action
 - total volume of SF6 gas required per circuit breaker at operating pressure.
10. Control Power Requirement:
- Tripping (3 poles) current at rated supply voltage (220 V D.C.) A
 - Tripping (3-poles) current at 70% of supply voltage (220 V D.C.) A
 - Closing (3-poles) current at rated supply Voltage (220 V.D.C.) A
 - Closing (3-poles) current at 85% of supply

	voltage (220 V.D.C.)	A
	- tripping voltage, range, percent	
	- closing voltage, range, percent	
11.	Heaters	
	- connected continuously	A
	- connected by thermostat	W
12.	Noise performance (circuit breaker operation)	
	- measurement standard	
	- noise level	db
	- distance	m
13.	Interrupters	
	- type of main contact, arcing contact & aux. Contacts	
	- material of main contact/arcing contacts, silver coated or not.	
	- contact pressure kg/mm.	
	- Number of interrupters per pole	
	- Break length of an interrupter	mm
	- Length of contact travel	mm
	- Rate of contact travel at tripping	m/sec
	- Rate of contact travel at closing	m/sec
14.	First pole to clear factor	
15.	Whether fixed trip or trip free	
16.	Details of Anti pumping device.	
17.	Rated line-charging breaking current.	A
18.	Rated single capacitor bank breaking current.	A
19.	rated small inductive breaking current	A
20.	Rated characteristics for short line fault	
21.	a) Rated transient recovery voltage for terminal faults.	
	b) Parameters as per IEC	
22.	Rated value of phase making current	KA(rms)
23.	Max. Interrupting capacity under phase opposition conditions	
24.	Capacity for interrupting in-rush current of transformer	
25.	Max. over voltage factor of the circuit breaker when switching off:	
	a) unloaded transformer	

- b) loaded transformer
 - c) open circuited lines
 - d) synchronous system
26. Details of operating counter
27. No. of auxiliary contacts their continuous rating and breaking capacities, including those used for circuit breaker operation and interlocking.
- i) Those closed when breaker is closed
 - ii) those open when breaker is open
 - iii) those adjustable w.r.t. the position of main contacts
28. Partial discharge level pico-coulombs
29. Radio interference level microvolt
30. Corona extinction voltage kV(rms)
31. Maximum impact loading on foundation during breaker opening and closing operations under fault conditions kg.
32. Seismic withstand value (Horizontal and vertical)
33. Tests to be conducted by the supplier at work and site. (Please give all details).
- a) type tests
 - b) Routine tests
34. Overall dimensions (LxBxH),m
35. Weight of breaker complete with operating mechanism, bushing, frame work: kg.
- a) with SF6 gas
 - b) without SF6 gas
36. Descriptive bulletins and drawings of the circuit breakers giving general details of construction.
37. Out of phase switching capability of the circuit breaker.
38. Please specify the suitability of the circuit breaker for restrike free operation of shunt reactor and power transformer carrying full load current.
39. What provision exists on the circuit breaker for uprating the capacity at a later time? Please mention details alongwith uprated capacities.
40. What are the guaranteed time difference between the first pole and last pole operation timing in m/sec.

41. Please describe the standard accessories to be supplied alongwith the breaker.
42. Has a copy of control scheme of circuit breaker attached alongwith the offer?
43. Please explain in detail, provision existing on GIS to reduce H.V. transients to acceptable values.
44. What are the guaranteed degraded values of B.I.L. Switching surges and 50 Hz rated values during the Life of equipment? Please supply test data to support This guarantee.

b) CGI BUS DUCT

S.No.	Description	Unit
1.	Manufacturer/Designing Firm	
2.	Type designation	
3.	Location of Manufacturing Plant	
4.	Nominal Voltage Class	kV
5.	Rated maximum voltage	kV
6.	Rated frequency	Hz
7.	1 minute power frequency kV rms - 250/2, 500 sec. Switching micro sec.	kV 1.2/50
8.	Rated short circuit current (1 second)	kA
9.	Maximum permissible operating temperature of current carrying parts.	°C
10.	Temperature rise of current carrying parts above _____ oC ambient	°C
11.	Maximum safe continuous current that can be carried with ambient temperatures of:	
	- 20°C in open air	A
	- 30°C in open air	A
	- 40°C in open air	A
12.	The consideration or component which limits the current rating:	
13.	SF6 pressure (absolute value)	
	- Normal at 20°C	Bar
	- "Refill" level	Bar
	- "Zone trip" level	Bar
14.	Maximum permissible moisture content of SF6 gas	
	- at the time of filling	ppm/vol
	- service limit	ppm/vol
15.	Guaranteed maximum SF6 gas leakage per year.	
	- complete bus duct	%
	- smallest compartment	%
16.	Temperature rise of enclosure at rated current (above _____ oC ambient)	
	- Outdoor	oC

17.	Capacitance per meter/phase	pf/m
18.	Resistance	micro-ohm/m
19.	Inductance	micro-henries/m
20.	Surge Impedance	ohms
21.	Grounding	
	Maximum potential rise of enclosure at _____ KA sym:	V
22.	Over pressure relief diaphragm	
	- material	
	- operating pressure	bar
23.	Maximum power losses per single phase per meter at rated voltage and current in: (at 40 deg.C ambient) As per IEEE (37.23-989)	
	- enclosure	KW/Meter/Phase
	- conductor	KW/Meter/Phase
	- total	KW/Meter/Phase
24.	Total weight of SF6 gas in the largest compartment	Kg.
25.	Average weight per single phase meter length (including SF6 gas)	Kg.
26.	Maximum span between bus duct supports	m
27.	Maximum unsupported conductor span	m
28.	Allowable deviation in support height	mm
29.	Insulator material	
30.	Conductor material	
31.	Conductor wall thickness	mm
32.	Conductor outside diameter	mm
33.	Enclosure material & its shape	
34.	Enclosure thickness	mm
35.	Enclosure inner diameter	mm
36.	Elbow wall thickness	mm
37.	Elbow inner diameter	mm

38. Maximum length of single phase gas compartment m
39. Describe the sliding contact design.
 - Material of contact
 - Is plating used? State material.
40. How is bonding between metallic parts of insulators, etc., performed?

Where spring loaded electrical connections are
Employed to bond a floating internal metallic part,
The following information is required.

 - Spring contact arrangement is shown in the attached Drawing nos.
 - State materials used in sliding surfaces
 - The spring pressure
 - Number of mechanical tests carried out.
 - Extent of service experience.
41. Is the enclosure bolted or welded?
42. Describe method of particle control employed
43. Are double O-ring seals employed between the sections?
44. Are bus duct lengths shipped with conductor and insulators, factory assembled?
45. Description of technique used to control thermal expansion in:
 - conductor
 - enclosure
46. Which type of bus duct (field weld type/flanged type) is being offered?
47. Shape and cross sectional area of conductor mm²
48. Current density A
49. Standard length of each unit m
50. Distance between phases center to center mm
51. Details of flexible joints
52. Details of termination at transformer end
53. Silver coating at joint-thickness and length
54. Enclosure burn through time at rated short circuit current Sec.

55.	Enclosure design pressure	kg/cm ²
56.	Enclosure rupturing pressure	kg/cm ²
57.	Barrier insulator rupturing pressure	kg/cm ²
58.	Maximum movements due to expansion, and/or contraction	
59.	Lateral	mm
60.	Longitudinal	mm
61.	Maximum forces at interface tensile,	kg.
	Compressive	kg.
62.	tolerance on positioning of flanges	mm
63.	Maximum permissible differential settlements (vertical) due to settlement of foundations	
64.	Arrangement of earthing	
65.	Type of cooling	
66.	Minimum creepage distance over insulator	
67.	Conductor treatment (Ventilation, painting)	

Sl.No.	Description	unit
<u>B1)SF6-TO-AIR BUSHING</u>		
1.	Manufacturer	
2.	Location of Manufacturing Plant	
3.	Material	
4.	Rated voltage	kV
5.	Rated continuous current	A
6.	Rated short-time current for 1 second	kA
7.	Rated insulation level - dry and wet power frequency with stand voltage - 1.2/50 microsecond lightning impulse withstand voltage - 250/2,500 microsecond switching impulse withstand voltage.	kV (rms) kV(peak) kV(peak)
8.	Corona extinction voltage	kV (rms)
9.	Rated BIL (Crest)	kV
10.	Rated power frequency withstand voltage	kV rms
11.	External Strike Distance: Phase-to-ground Phase-to-phase	mm mm
12.	External creep distance	mm
13.	Cantilever strength	Nm
14.	Acceptable terminal load	N
15.	Colour of porcelain/composite material	
16.	Weight	Kg
17.	Explain how the dielectric stress is controlled at the top and at the bottom:	
18.	Partial discharge level, pico-coulomb	
19.	Radio interference level, microvolt	
20.	Has equipment been type tested and to which standards?	
21.	Dimension of single-phase bushing	mm
22.	Description of mounting steel structures for bushings.	

c) DISCONNECTS/GROUNDING SWITCHES

C.I. Isolator Switches

Sr.No.	Description	Unit
1.	Manufacturer	
2.	Type & Designation	
3.	Rated voltage	(kV)
4.	1.2/50 microsecond lightning impulse withstand voltage	kV (peak)
	<ul style="list-style-type: none"> - Between line terminals and ground - Between terminals with disconnecting switch in Open position. 	
	250/2,500 microsecond switching impulse withstand voltage	kV (peak)
	<ul style="list-style-type: none"> - Between line terminals and ground - Between terminals with disconnecting switch in Open position. 	
5.	Dry 1 minute Power Frequency withstand voltage	kV (RMS)
	<ul style="list-style-type: none"> i) Between terminals and ground. ii) Between terminals with disconnecting switch in open position 	
6.	Rated frequency	Hz
7.	Rated normal current	A
8.	Rated peak short circuit current	KA
9.	Rated Short Time Current	KA (Peak)
	<ul style="list-style-type: none"> i) 1 sec. ii) 3 sec. 	
10.	Rated peak withstand current	KA (peak)
11.	Rated inductive breaking current	A
12.	TRV caused by breaking/making inductive current	KV
13.	Rated capacitive breaking current	A
14.	TRV caused by breaking /making capacitive current	KV
15.	Rated insulation level	

	- 1-minute power frequency withstand voltage	kV (rms)
	- 1.2/50 microsecond lightning impulse withstand voltage	kV (peak)
	- 250/2,500 microsecond switching impulse withstand voltage	kV(peak)
16.	Maximum temperature rise above ambient at rated current	
	- contacts	oC
	- hottest part	oC
17.	Motor operating mechanism	
	- closing current	A
	- opening current	A
	- closing time	S
	- opening time	S
	- operating voltage and range	V
18.	Design data	
	- type of contacts	
	- contact pressure	
	- surface treatment and thickness of surface coating/silver electrolytic plating.	
	- overtravel distance after contact made	mm
	- distance between fully open contact	
	- current density at the minimum cross section of switch blade.	
	- speed of break	mm/s
19.	Partial discharge level	pico-coulombs
20.	Corona extinction voltage	kV(rms)
21.	Radio interference level	microvolt
22.	Auxiliary switches	
	- No. of NO and NC contacts	
	- Rated voltage	
	- Rated current	
	- Test voltage	
23.	No. of operations which the switch can withstand without any need for inspection.	
24.	Type of mounting	
25.	No. of pole per phase	
26.	Safety Factor taken into account while designing the isolator	
27.	Whether arcing contacts provided? If so, give type and material used.	

28. Wt. Of 3 pole isolating switch
- | | |
|---------------------------|-----|
| - with earthing blades | Kg. |
| - without earthing blades | Kg. |
29. Type of interlock between main isolator and earthing switch
30. Has equipment been type tested and to which standards?
31. Fault making capability (for quick acting grounding switches)
32. Rated maximum time duration of short circuit.
33. Rated mechanical terminal load.
34. Rated supply voltage of operating devices and auxiliary circuits.
35. Rated pressure of SF6 gas.
36. Minimum distance between poles with regard to insulation and forces caused by short circuit currents.
37. Tests to be conducted by the Manufacturer at works and site:
- i) Type tests
 - ii) Routine tests

Sl.No.	Description	Unit
--------	-------------	------

C II Grounding Switches/High speed fault making grounding Switch

- | | |
|--|-----------|
| - Manufacturer | |
| - Type designation | |
| - Maximum permissible operating voltage | kV |
| - Maximum make and carry current for 1 sec | KA(Peak) |
| - Rated inductive breaking current | A |
| - TRV caused by breaking/making inductive current | kV |
| - Rated capacitive current | A |
| - TRV caused by breaking/making capacitive current | kV |
| - Motor operating mechanism | |
| - Closing current | A |
| - Closing time | S |
| - Opening current | A |
| - Opening time | S |
| - Design data | |
| - Ground connection insulation | kV |
| - Type of contacts | |
| - Over travel distance | mm |
| - Distance of fully open contacts | mm |
| - Speed of make | mm/s |
| - Partial discharge, level | pico- |
| coulomb | |
| - Corona extinction voltage | kV(rms) |
| - Radio interference level | microvolt |

Has equipment been type tested and to which standards?

Dia of NO and NC contacts, its rated voltage and current

d) CURRENT TRANSFORMERS

(particulars for different groups of CT's be given on separate sheet)

Sl.No.	Description	Unit
1.	Name of Manufacturer	
2.	Type	
3.	Manufacturer's type designation	
4.	Rated voltage	
5.	Normal continuous rating	
6.	Normal ratio of transformation	
7.	Rated primary current	
8.	Rated secondary current	
9.	Numbers of cores	

For Each Type of C.T.

Sr.No.	Description	Unit
--------	-------------	------

10.

C O R E	Rated Output (VA)	Class of accuracy	Accuracy limit factor	Current error at rated primary Current %	Phase displacement at rated primary current (Minutes)	Composite errors at rated acc- uracy limit primary current
------------------	-------------------------	----------------------	-----------------------------	---	--	---

I
II
III
IV
V

11.

C O R E	Knee point voltagev	Secondary limiting voltage	Secondary winding resistance	Exciting current	Instrument security current
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I
II
III
IV
V

Sr.No.	Description	Unit
--------	-------------	------

12. One second over current factor time rated current.
13. Rated current dynamic (Peak value in amps)
14. Rated continuous thermal current temperature rise over ambient oC
15. One minute power frequency dry withstand test voltage kV(rms)
16. One minute power frequency wet withstand test voltage kv(rms)
17. 1.2/50 microsecond impulse withstand test voltage kv(peak)
18. One minute power frequency withstand test voltage on secondaries kV(rms)
19. Total weight kg.
20. Magnetisation curves of CT cores
21. Mounting details
22. Overall dimensions
23. Tests Proposed by the Manufacturer at Works and site:
 - i) Type test
 - ii) Routine test

e) VOLTAGE TRANSFORMER

		Core I	Core II	Core III
Sr.No.	Description			Unit
1.	Name of Manufacture			
2.	Type			
3.	Rated primary voltage			
4.	Rated secondary voltage			
5.	Rated output per phase			
6.	Rated frequency			Hz
7.	standard values of rated voltage factor			
8.	Limits of temperature rise.			
9.	One-minute power frequency withstand voltage test			kV (rms)
10.	1.2/50 micro second. Impulse withstand voltage test			kV (peak)
11.	Total weight			(Kg.)
12.	Limits of voltage error and phase displacement in %.			
13.	Error angle			
14.	Voltage error			
15.	Accuracy class			
16.	voltage factor and rated time			
17.	Tests to be conducted by the manufacturer at works /site:			
	i) Type tests			
	ii) Routine tests			

f) SF6 GAS

Sr.No.	Description	Unit
1.	Name of manufacturer	
2.	Electrical properties (Please give details).	
3.	Compatibility with material used in switchgear.	
4.	Impurities in percentage (Please mention details of impurities)	
5.	Size of the Cylinder in which gas is proposed to be supplied	
6.	Condensation temperature.	
7.	Physical properties. (Please give details)	
8.	Certification that gas meets all the properties requirement.	
9.	Tests to be conducted by the manufacturer at works.	
10.	Tests proposed to be conducted at site to detect and Limit the moisture content in gas compartments.	
a)	- normal pressure	kg/cm ²
	- normal operating density	g/cc
	- maximum pressure to maintain dielectric insulation for 420-KV no load.	g/cc
	- maximum leakage rate per year at normal pressure	percent
	- maximum permissible moisture content by weight	ppm
	- permissible variation in ambient temperature	
	- Details of gas filters	
	- Effective life of filters	
	- Test pressure for gas system	kg/cm ²
	- Constituents of gas in percent of weight & volume of SF6	%
b)	Alarm Levels	
	- First alarm level, circuit breakers	kg/cm ²
	- Second alarm level, circuit breakers	kg/cm ²
	- First alarm level, all other components	kg/cm ²
	- Second alarm level, all other components	kg/cm ²
	Gas Monitoring Devices	
	"Describe (with the aid of sketches) the type and location of gas density, gas pressure, gas moisture content and other fault monitoring devices which shall be supplied.	
	Pressure Relief Devices	
(a)	Rupturing pressure	kg/cm ²
(b)	Time to rupture	seconds
(c)	Describe (with the aid of a sketch) location and quantity of pressure relief devices used in each gas section.	

g) MOTOR/CONTROL GEAR

Sr.No.	Description	Unit
1.	Name of manufacturer.	
2.	Manufacturer's type and designation	
3.	Standards to which the motor conform (IS/IEC)	
4.	Rated output in KW	
5.	Speed in rpm at rated output.	
6.	Rated voltage, number of phases and frequency.	
7.	Class of insulation.	
8.	Type of duties, values and duration of over load.	
9.	Class of rating	
10.	Type of rotor (Squirrel cage or slip ring)	
11.	Efficiency of motor at 50%,75% and 100% loads.	
12.	Methods of starting of the motor.	
13.	Starter's type.	
14.	Starting torque as % rated full load torque and starting current.	
15.	Details of shaft extensions.	
16.	Type, make and current capacity of main control switch.	
17.	type, make and current capacity of motor control switches	

Sr.No.	Description	Unit
h)	SURGE ARRESTORS	
	- Manufacturer	
	- Type designation	
	- Class of arrester	
	- Rated continuous operating voltage (MCCV),	kV
	- Maximum discharge current (8/20 microsecond wave)	kA
	- Maximum 0.5 microsec discharge voltage	kV
	- Impulse discharge voltage (residual voltage) at 10 kV (8/20 microsecond current wave).	kV(Peak)
	- maximum switching surge protective voltage	kV(Peak)
	- Partial discharge level	pico-coulomb
	- Corona extinction voltage	kV(rms)
	- Radio interference level, microvolt at 266	kV(rms)
	- High current short duration value	
	- Short circuit capability & class of pressure relief	
	- Long duration discharge class	
	- Has equipment been type tested and to which standards?	

i) INSULATORS FOR GI SWITCHGEAR

(Please Mention Details Separately for each type of insulator used)

Sr.No.	Description	Unit
1.	Manufacturer	
2.	Type of Insulators used.	
3.	1-minute power frequency dry withstand test voltage	kV
4.	Dry flashover value	kV(RMS)
5.	Wet flashover value	kV(RMS)
6.	1.2/50 Impulse withstand test voltage	kV(peak)
7.	Creepage distance	mm
8.	Puncture value of insulator in SF6 gas	kV
9.	Weight of Insulators in the SF6 GIS enclosure.	Kg.

Sr.No.	Description	Unit
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j) DESIGN CLEARANCE

Manufacturer shall state the following minimum insulating clearance, at nominal rated SF6 gas pressure and rated voltage/BIL voltage.

- a) Main bus to ground
- b) Circuit breaker
 - to ground
 - across contact
- c) Isolator switches
 - to ground
 - across contacts
- d) Safety grounding switches
 - to ground
 - across contacts
- e) High-speed make proof grounding switches
 - to ground
 - across contacts
- f) SF6 –to-air bushings

k) STEEL SUPPORT STRUCTURES

(a) Structural steel

- minimum guaranteed yield point kg/cm^2
- ultimate tensile strength kg/cm^2

(b) Bolts and nuts

- minimum tensile strength of bolts kg/cm^2
- proof load on nuts kg

(c) Manufacturer

I) WEIGHTS AND DIMENSION

- | | | |
|-----|---|-----|
| (a) | Shipping weight of heaviest package | Kg. |
| (b) | Dimensions of largest package, | mm |
| (c) | Shipping weight of all special lifting devices, wrenches and tools etc. | |
| (d) | Shipping weight of SF6 gas treatment unit | |
| (e) | Weight of each type of switchgear bay module | |
| | - Transmission line | kg. |
| | - Generator line incoming feeder | kg. |
| | - bus coupler bay module | kg. |
| (f) | Untanking height, mm(i.e. height under hook required for vertical breaker arrangement). | |
| (g) | Shipping weight of SF6 gas cylinders required for first filling and testing. | |
| (h) | Approximate shipping dimensions of all gas cylinders | |

Date:

Place:

Signature of Bidder

Name:

Status:

**Whether authorised attorney
of tendering company
Name of tendering Company**

ANNEXURE – III

MANUFACTURER, PLACE OF MANUFACTURE, TESTING AND INSPECTION

Sl.No.	Item	Manufacturer Place of Manufacture	Place of testing and Inspection
1.	SF6 Breakers		
2.	C.Ts		
3.	V.Ts		
4.	Disconnectors and Ground switches.		
5.	Bus ducts.		
6.	Lightning Arrestors.		
7.	Complete SF6 Switch Gear assembly.		

Date:

Place:

Signature of Bidder

Name:

Status:

**Whether authorised attorney
of tendering company**

Name of tendering Company

ANNEXURE-IV

SCHEDULE OF DEVIATIONS

S.No.	Clause No. & Description	Deviation	Reason

Date:

Place:

Signature of Bidder

Name:

Status:

**Whether authorised attorney
of tendering company**

Name of tendering Company

ANNEXURE-V

DELIVERY AND COMPLETION PERIOD

Sr.No.	Item	420 kV SF6 Switchgear Complete with Accessories.
1.	Period required to commence work from tender acceptance.	
2.	Period for supplying drawings for engineer's approval.	
3.	Period when plant will be ready for inspection before dispatch.	
4.	Period when the plant will be received At Indian Port.	
5.	Period by which all the equipment will be completely erected, tested and commissioned under supervision of firm's Engineers.	

Date:

Place:

Signature of Bidder

Name:

Status:

**Whether authorised attorney
of tendering company**

Name of tendering Company

Annexure - VI

SCHEDULE OF RECOMMENDED SPARE PARTS

S.No.	Particulars/ Description	Quantity	Manufacturer / place & country of manufacture	Remarks

Date:

Place:

Signature of Bidder

Name:

Status:

**Whether authorised attorney
of tendering company**

Name of tendering Company

ANNEXURE-VII

SCHEDULE OF DRAWINGS

Sr. No.	Title of Drawing enclosed	Drawing No.
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Date:

Place:

Signature of bidder

Name:

Status:

**Whether authorized attorney
of tendering company**

ANNEXURE – VIII

THE SUPPLIER SHALL FURNISH HERE A LIST OF SIMILAR EQUIPMENT SUPPLIED BY HIM WHICH ARE PRESENTLY IN SERVICES

Sl.No.	Name of Installation	No. and rating	Customer	Year of each Unit of Installation
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Date:

Place:

Signature of Bidder

Name:

Status:

**Whether authorised attorney
of tendering company**

Name of tendering Company

ANNEXURE – IX

TEST FACILITIES OWNED BY BIDDER

(To be filled in by the bidder)

Sr,No.	Description of Test	Facility	Tests which can be performed	Remarks
	.1.	2.	3.	4.

Date:

Place:

Signature of Bidder

Name:

Status:

**Whether authorised attorney
of tendering company**

Name of tendering Company

ANNEXURE – X

SCHEDULE OF TYPE TEST, ROUTINE TEST & PERFORMANCE TESTS

In this Schedule bidder shall offer his comments/opinion for conducting type tests, routine tests and performance tests. The bidder shall furnish information regarding method, procedure and testing programme for the tests enumerated in clause No.7.25.

Date:

Place:

Signature of Bidder

Name:

Status:

**Whether authorised attorney
of tendering company**

Name of tendering Company

ANNEXURE-XI

INFORMATION REGARDING THE ITEMS TO BE MANUFACTURED BY SUB-SUPPLIERS/CONTRACTORS

S.No.	Item	Name of the manufacturer	Place of manufacture testing and inspection

Date:

Place:

Signature of Bidder

Name:

Status:

**Whether authorised attorney
of tendering company**

Name of tendering Company

ANNEXURE-XII

**SPECIFIC EXPERIENCE: LIST OF TURNKEY WORKS PERFORMED FOR SF6
GIS EQUIPMENT IN LAST 5 YEARS**

Separate form for each project shall be filled in the by the bidder

S. No.	Details of the system	Name of the project, Name of the customer and his full address & country	Specific information about the installed system	Date of award of contract	Date of completion of supply	Value of contract	Remarks
1	2	3	4	5	6	7	8
1.	Design, installation & putting into operation the SF6 GIS Equipment						

Notes :

Bidders should note that filling of this form is compulsory

Date:

Place:

Signature of Bidder

Name:

Status:

**Whether authorised attorney
of tendering company**

Name of tendering Company

ANNEXURE-XIII

**SCHEDULE OF DESIGN CALCULATIONS AND STUDIES TO BE FURNISHED
ALONGWITH THE BID**

The bidder shall furnish the detailed studies and calculations as mentioned below
alongwith the bid.

a) For enclosures:

Calculations for deciding thickness of enclosure of GIS, busbars and bus duct so
as to withstand an internal flashover.

b) Busbar and CGI Bus duct:

- i) Calculations for selection of size of conductor and enclosure.
- ii) Calculations for deciding insulator span based on dynamic short circuit stresses.
- ii) Calculations for thermal withstand capacity for short circuit current.

c) Surge Arrestors

- i) Study report establishing that the characteristics of the surge arrestors to be provided by GIS manufacturer and the location chosen to provide the Security ratio of at-least 1.3 under all conditions for protection of generator step up transformer. This study report should highlight the technical comments on the proposed rated voltage; the long duration class and the energy handling capacity.

Date:

Place:

Signature of Bidder

Name:

Status:

**Whether authorised attorney
of tendering company**

Name of tendering Company

ANNEXURE-XIV

**LIST OF CONTRACTS IN HAND AND BIDS SUBMITTED FOR SF6 GIS
EQUIPMENTS**

S. No.	Name of project	Name of customer, his full address & country	Nature of installation of the project such as generating station, oil refinery, large scale petro-chemical etc.	Details of SF6 GIS equipments installed	Date of award of contract	Present	Expected date of completion	Value of contract	Remarks
1	2	3	4 (a)	4(b)	5	6	7	8	9
1.	List of contracts in hand								
2.	List of bids submitted								

(To be filled in by the bidder)

Notes:

- i) In case of joint venture, this schedule shall be furnished by each partner separately.

Date:

Place:

Signature of Bidder

Name:

Status:

**Whether authorised attorney
of tendering company**

Name of tendering Company

ANNEXURE-XV

DETAILS OF THE MANUFACTURING CAPACITY OF THE ORGANISATION

Date:

Place:

Signature of bidder

Name:

Status:

**Whether authorized attorney
of tendering company**

ANNEXURE-XVI

DETAILS ABOUT THE TECHNICAL AND MANAGERIAL PERSONNEL AVAILABLE WITH THE FIRM RESPONSIBLE FOR DESIGN AND/OR MANUFACTURE AND INSTALLATION OF SF6 GIS EQUIPMENTS

S.No.	Category of personnel	Personnel having experience pertaining to works of similar size & nature	Total no. of key personnel
A.	Technical personnel		
i)	Design personnel		
ii)	Production personnel		
iii)	Quality assurance personnel		
iv)	Supervisory engineers on site erection		
v)	Testing and commissioning engineer		
B.	Training Department		
i)	Managerial personnel		
ii)	Servicing personnel		
iii)	Any other category bidder desire to include		

Date:

Place:

Signature of Bidder

Name:

Status:

Whether authorised attorney of tendering company

Name of tendering Company

ANNEXURE-XVII

SCHEDULE OF PERIODICAL INSPECTION AND MAINTENANCE OF GIS

(Pursuant to clause 7.5)

In this schedule bidder shall furnish information about schedule of periodical inspection and maintenance of external and internal components of all switchgear assemblies/sub-assemblies equipment.

Date:

Place:

Signature of Bidder

Name:

Status:

**Whether authorised attorney
of tendering company**

Name of tendering Company

ANNEXURE-XVIII

**BIDDER'S COMMENTS ON PERFORMING SPECIAL TYPE TESTS AND EARTHQUAKE
WITHSTAND TEST**

(Pursuant to clause 7.25.3)
(to be filled in by the bidder)

In this schedule bidder should offer his comments/opinion about implication/effects of carrying type tests as covered under clause 7.25.3. The comments/opinion shall be given on each of the aforesaid tests.

Date:

Place:

Signature of Bidder

Name:

Status:

**Whether authorised attorney
of tendering company**

Name of tendering Company

ANNEXURE-XIX

BIDDER'S COMMENTS ON PERFORMING DIELECTRIC TESTS AT SITE

(To be filled by the bidder)

In this schedule bidder shall give his comments/opinion about necessity or otherwise for performing following dielectric tests on GIS bays and give detailed information about set up of test instruments/equipment and practicability about performing each of these tests at Rampur Hydro Electric Project site location of GIS. The space requirement, clearance to be maintained etc. for performance of these tests shall also be given.

- i) Oscillating lightning impulse test.
- ii) Oscillating switching impulse test.

Date:

Place:

Signature of Bidder

Name:

Status:

**Whether authorised attorney
of tendering company**

Name of tendering Company

ANNEXURE-XX

DIELECTRIC TESTS CARRIED OUT AT SITE AFTER ASSEMBLY OF GIS BAY DURING PAST TEN YEARS

(To be filled by the bidder)

Sr.No.	Name of GIS Installation	Voltage level	Location underground Indoor/ Outdoor	Dielectric test performed at site installation of GIS bays & Tests voltage	Remarks
1.	2.	3.	4.	5.	6.

Date:

Place:

Signature of Bidder

Name:

Status:

**Whether authorised attorney
of tendering company**

Name of tendering Company

ANNEXURE-XXI

QUALITY ASSURANCE PLAN

(To be filled in by the bidder)

In this schedule the bidder shall give the quality assurance plan he proposes to be followed during manufacturer, erection, testing and commissioning of GIS and GI Bus-duct

Date:

Place:

Signature of Bidder

Name:

Status:

**Whether authorised attorney
of tendering company**

Name of tendering Company

ANNEXURE-XXII

SCHEDULE OF REQUIREMENTS

S.No	Description	Quantity	Remarks
1	2	3	4
1.	Double bus bar system - GIS (Details as per clause 7.30.1 a))	1 Set	
2.	Bus coupler Bay (Details as per clause 7.30.1 b))	1 Set	
3.	Generator Transformer feeder bays (Details as per clause 7.30.1 c))	6 Nos.	
4.	Line feeder bays (Details as per clause 7.30.1d))	4 Nos.	
5.	Control Cables (Details as per clause 7.30.1 e))	Lot	
6.	Power cables (Details as per clause 7.30.1 f))	Lot	
7.	SF6 gas for first filling in returnable (or non-returnable) steel bottles/cylinders.	Lot	
8.	Galvanized steel structures for mounting the switchgear including all fittings etc.	Lot	
9.	Complete material fitting etc. required for the grounding of GIS.	Lot	
10.	First filling of SF6 gas, gas processing unit, switchgear handling equipment, maintenance instruments, materials, consumables, tools, devices, testing equipment, instruments, complete installation, testing, commissioning and placing into successful operation, applicable standards etc as per clause no. 7.30.2 a to h)		
11.	Spare Parts (Mandatory) as per clause no. 7.30.2 g)		

Note: Bidder is to give price break up for all items separately.

Date:

Place:

Signature of Bidder

Name:

Status:

**Whether authorised attorney
of tendering company
Name of tendering Company**