

VOLUME-2
PART- I
Section-7
11 kV Switchgear

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7. 11 kV Switchgear

7.1 Intent of Specifications

The intent of these specifications is to define and cover the scope of work under this section which covers the provision of labour, tools, plants, materials and performance of work necessary for the design, manufacture, quality assurance, quality control, shop assembly, shop testing, delivery at site, storage at site, erection, acceptance testing, commissioning, performance testing, handing over to Purchaser and guarantee for trouble free operation of 11 kV Indoor switchgear for Keyi Hydro Electric Project, Arunachal Pradesh as per the specifications hereunder, complete with all auxiliaries, accessories, any items not specifically mentioned but required for the satisfactory operation of equipment, spare parts and warranting a trouble free safe operation of the installation.

It is not the intention to specify the minute details/smallest items to deliver a functional system or to define the standard manufacturing practice but to outline the performance, constructional, operational and guaranteed requirements. It is the responsibility of the contractor to ensure these requirements.

7.2 Scope of Supply

7.2.1 Material

One (1) set of 11 kV, 2000 A, Three Phase, 50 Hz, 31.5 kA for 1 sec., Aluminium bus bar, metal enclosed, air insulated with draw out type Vacuum Circuit breakers (VCB) as bus coupler breaker as per attached electrical SLD shall comprise the following Panels:

1. 2 nos. generator incomer feeders from each generator each complete with following equipment:
 - 11 kV electrically operated draw out type Vacuum circuit breaker with rated continuous current rating as per system requirement and rupturing current capacity of 31.5 kA complete with all accessories
 - Control / selector switches /push buttons
 - Indicating lamps
 - Current and Voltage Transformers
 - Multifunction meters
 - Annunciation windows
 - MCBs, Space heaters with thermostat, convenience outlets etc.
 - Terminal blocks for cables
 - Test terminal blocks for CT wires
2. Two (2) nos. outgoing feeders to 15 MVA, 11/132 kV Generator transformers complete with the following equipment: -

- 11 kV electrically operated draw out type Vacuum circuit breaker with rated continuous current of 2000 A or as system requirement and rupturing current capacity of 31.5 kA complete with all accessories
 - Control / selector switches /push buttons
 - Indicating lamps
 - Current & voltage transformers as shown in SLD
3. Two (2) nos. - Panels for Outgoing feeders to 500 kVA, 11/0.433 kV station service transformers, each complete with all the equipment as listed below.
- 11 kV electrically operated draw out type Vacuum circuit breaker with rated continuous current of 2000 A and rupturing current capacity of 31.5 kA complete with all accessories.
 - Control / selector switches /push buttons
 - Indicating lamps
 - Current & voltage transformers as shown in SLD
 - Multifunction Meter
4. Two (2) no. - Bus PT Panel
5. Breaker handling trolley-1 No.
6. Safety and operational Interlocks
7. Coordination and provision of necessary contacts and/or ports for integration with plant SCADA system
8. Spare parts to be discussed separately.
9. Special Tools and instruments.
10. One Lot of earthing of panels.
11. One earthing trolley able to earth any of the feeders as required.

7.2.2 Services

- Transportation and delivery to site including all logistics and proper site storage and preservation as per manufacturer's recommendation.
- Cable schedule
- Site installation and commissioning
- Consumables required during erection
- Field / touch-up painting including all painting materials
- Performance and field acceptance testing as per the relevant clause & applicable standards of this section and submission of report

- Training of Purchaser's personnel including operation and maintenance staff
- All the technical documentation including preparation and submission of O & M manuals

7.3 Specific Parameters and Layout Conditions

7.3.1 Layout and General Arrangement

11 kV indoor switchgear is proposed to be located in powerhouse. Two (2) No. 11kV incoming feeder from generator shall be connected by XLPE cables to this switchgear. Two (2) Nos. outgoing feeders to step up generator transformer located in switchyard outdoor shall be taken by XLPE cables. Two outgoing feeders for 500 kVA, 11/.433 kV station service transformers located adjoining to power plant shall also be taken by XLPE cable.

7.3.2 Operating conditions

Normal operation shall be defined as operation with operating parameters within the following ranges:

- System parameter- Normal range
- Voltage- 90 % to 110 % of rated value
- Frequency- 47.5 Hz to 51.5 Hz

7.3.3 Design considerations

The 11 kV switchgear shall be capable of carrying the 2000 A rated continuous and 31.5 kA rms short circuit current without exceeding the specified temperature limitations. The switchgear breaker compartment shall be fully draw out type.

All necessary interlocks shall be provided.

7.4 Rating and Functional Characteristics

7.4.1 General

The switchgear assembly, circuit breakers, CT's, VT's, lightning arresters, bus bars, etc. shall be suitable for following system parameters:

7.4.2 Bus Bars/ Cubicles

i)	Rated system voltage	11 kV
ii)	Highest system voltage	12 kV
iii)	No. of phases	Three
iv)	System earthing	Neutral effectively earthed
v)	Frequency	50 Hz

vi)	Continuous current rating of bus bars	2000 A
vii)	Short time withstand current capacity	31.5 kA for 1sec.
viii)	Peak withstand current	80 kA

7.4.3 Circuit Breakers

The circuit breakers shall be triple pole horizontal draw-out type and shall comply with the requirement of IS 13118/IEC 62271-100 & 62271-1. The circuit breakers shall have the following ratings:

i)	Number of poles	3	
ii)	Nominal system voltage	11 kV	
iii)	Highest system voltage	12 kV	
iv)	Type	Vacuum	
v)	Rated and continuous current	2000 A	
vi)	Symmetrical breaking current capacity	31.5 kA	
vii)	Short time withstand current	31.5 kA for 1 sec.	
viii)	Short circuit make-up current	80 kA (peak)	
ix)	Total opening time cycles	Not more than four	
x)	Total closing time cycles	Not more than five	
xi)	Duty cycle	O-.3s-CO-3 min-CO	
xii)	Operating mechanism energy type	Spring charged stored	
xiii)	Control voltage of		
	a)	Closing coil	110 V DC (+ 10%, - 15%)
	b)	Tripping coil	110 V DC (+ 10%, - 30%)
	c)	Spring charging motor	110 DC (+ 10%, - 15%) / 230 V AC (+ 10%, - 15%)

7.4.4 Current Transformers

Resin cast current transformers conforming to latest addition of IS 2705, Part I, II, III & IV / IEC 60044 and latest IECs. Except for CTs 1,2 & 3, all CTs shall be mounted inside the 11kV switchgear board. CTs 1,2 & 3 shall be mounted inside neutral grounding cubicle. 11kV switchgear supplier shall co-ordinate & cooperate with the neutral grounding cubicle supplier.

The current transformers shall be designed to withstand the thermal and mechanical stresses resulting from the maximum short circuit current. The current transformers shall be suitable for the purposes intended.

The secondary terminals shall be brought out in a separate compartment for easy access and provision shall be kept for shorting the current transformers secondary terminals.

i)	Nominal system voltage	11 kV
ii)	Highest system voltage	12 kV
iii)	One minute power frequency withstand voltage	28 kV (rms)
iv)	1.2/50 microsecond impulse withstand voltage	75 kV (peak)
v)	No. of phases	Single
vi)	Short time thermal current rating	31.5 kA for 1 sec.
vii)	Short time dynamic current rating	80 kA
viii)	Details of transformation ratio, burden, accuracy class, etc.	As per Table IIA , II B, IIC & IID

7.4.4.1 CT Rating and Accuracy Class

Ratio	Purpose	VA Burden	Accuracy Class / Accuracy Limit factor	Min. Knee Point Voltage (V)	R _{CT}	Location
	Generator protection		5P20 PS 0.5S			Neutral grounding cubicle or Generator Terminal Box
	Generator protection		5P20 PS 0.5S			LAVT or 11kV Cubicle

2 sets of CTs (6 Nos) for Generator Transformer incomers below:

			Limit factor			
	Diff. core 1		PS			11kV Panels

CTs for generator step up transformer on 33 kV side and outgoing lines

Ratio and Voltage Class	Purpose	VA Burden	Accuracy Class / Accuracy Limit factor	Min. Knee Point Voltage (V)	R _{CT}	Location
	Core-1 Diff. Core-2 Prot. Core-3 Met.		PS 5P20 0.5S			Outdoor
	Core-1 Met. Core-2 Prot. Core-3 Met.		0.2 5P20 0.2		.1	-do -

2 sets of CTs for 500 kVA Transformer on 11 kV side

Ratio	Purpose	VA Burden	Accuracy Class / Accuracy Limit factor	Min. Knee Point Voltage (V)	R _{CT}	Location
	Core-1 Protection Core-2 metering	15	5P10 0.5S	^_ ^_	^_ ^_	11kV Panel

7.4.5 Voltage Transformers

The voltage transformers shall be of cast resin type and shall consist of three single phase units. The potential transformers shall conform to the requirement of IS 3156 / IEC 60044 and shall be rated as follows:

i)	No. of Voltage Transformers	2 at main bus
ii)	Rated primary voltage	11 / $\sqrt{3}$ kV
iii)	No. of secondary windings	3
iv)	Rated transformation ratio	11 kV / A 3 / $110/\sqrt{3}$ / $110/\sqrt{3}$ / $110/\sqrt{3}$
v)	Rated output	
	a) For bus PT's	
vi)	Accuracy class	
	a) Winding 1	0.5
	b) Winding 2	3 P

	c)	Winding 3- Synchronizing	0.5
vii)	Purpose		Winding 1 for Metering Winding 2 for Protection Winding 3 for Synchronizing
viii)	Rated voltage factor		1.2 cont., 1.9 for 30 seconds.
ix)	One minute power frequency withstand test voltage		
	a)	Primary winding	28 kV (rms)
	b)	Secondary winding	3 kV (rms)
x)	1.2/50 micro second/impulse		75 kV (peak)

7.4.6 Disconnecting Switches

Breakers being draw out trolley type, disconnecting switches have not been provided. The disconnecting switches may be provided by the contractor if required from safety point of view.

One number earthing trolley of suitable rating shall be provided for earthing any panel of the all switch board when required.

7.5 Performance Guarantee

11kV indoor switchgear along with all auxiliaries & accessories shall be capable of performing intended duties under specified conditions. The Contractor shall guarantee the reliability and performance of the individual equipment as well as of the complete system. The generator incomer panel and step up transformer switchgear panel have to perform the duty of synchronisation to be controlled from synchronisation panel.

7.6 Standards

The system and equipment shall be designed, built, tested and installed to the latest revisions of the following applicable standards. In the event of other standards being applicable they will be compared for specific requirement and specifically approved during detailed engineering for the purpose:

Standards	Description
IEC 62271-200	AC metal enclosed switchgear & control gear for rated voltages above 1 kV & up to & including 52 kV.
IS: 13947	Degree of protection provided by enclosures for switchgear.
IS: 1901	Specification for visual indication lamps
IS: 375	Marking & Arrangement for switchgear, bus bars, main connections & Auxiliary wiring
IS: 5	Colours for ready mixed paints & enamels.

IS: 13118	High Voltage Alternating current circuit breakers.
IEC: 62271-100	High Voltage Alternating current circuit breakers.
IEC:62271-1	Common specifications for high voltage switchgear & control gear.
IS: 2705	(Part I, II, III & IV), Current Transformers
IS: 3156	(Part I, II, III & IV), Voltage Transformers.
IEC: 61869	Instrument Transformers
IS: 1248	Indicating Electrical measuring instruments.
IS: 3231	Electrical relays for Power Systems.
IEC-60099-4.	Metal oxide surge arresters without gates for A.C. systems.

7.7 Design and Construction

7.7.1 Type

The switchgear shall be indoor, free standing, sheet metal clad, modular, draw-out type and shall be fully compartmentalised.

7.7.2 Sheet Steel Thickness

Switchgear panels shall be made of cold rolled sheet steel of not less than 2 mm thickness suitably reinforced to provide rigid flat level surfaces resistant to vibration during transportation and installation having smooth finish and elegant appearances.

7.7.3 Dust Tightness

The Switchgear enclosures shall be totally enclosed design, dust tight and vermin proof. All doors, panels and removable covers shall be gasketed in and around with neoprene gaskets to render the equipment effectively dust proof. Ventilating louvers/pressure relief flaps shall be of such a design so as not to permit entry of dust or water droplets.

7.7.4 Degree of Protection

The switchgear enclosures shall provide adequate degree (degree of protection not less than IP 42) of protection against contact with live parts, entry of dust and water as stipulated in specific technical requirements.

7.7.5 Space Heater and Plug Points

Each panel shall be equipped with space heater to prevent moisture condensation within the enclosure and shall be complete with MCB, thermostats and auxiliary relay (if required). The space heaters shall be suitable for automatic "ON" and "OFF" operation. The setting temperature range shall be furnished in the tender. The space heater shall be suitable for operation on 230 V + 10%, - 15% AC supply. The MCB shall be mounted in an easily accessible position inside the cubicle. A 230 V, 1 phase, 5 A, 50 Hz, AC, 5

pin plug point, shall be provided in the interior of each panel with an ON- OFF switch for connection of hand lamp.

The Contractor shall furnish the single-phase distribution of space heater supply as well as single-phase supply for receptacles.

7.7.6 Compartmentalisation

Switchgear design shall comprise of fully compartmental execution having separate vertical sections for each circuit. In each panels separate segregated compartments of earthed metal partitions shall be provided for the following components:

- Bus bars.
- Circuit Breakers.
- Current Transformers, Voltage Transformers, Lightning Arresters and Cable Boxes.
- Metering compartments for instruments relays and control devices.

Circuit breaker and instrument/relay compartments shall be provided with hinged doors with facility for padlocking.

The circuit-breaker compartment shall be totally segregated from bus bar and cabling compartments by the use of seal-off bushings.

Instruments and relays shall be flush mounted on the front of the cubicle. The door shall be supported by strong hinges and braced in a manner to ensure freedom from sagging and bending.

7.7.7 Foundation Channels

All necessary foundation channels along with other hardware foundation bolts/anchors meant for mounting the switchgear shall be supplied and despatched well in advance.

7.7.8 Extensibility

Structure, buses and control wiring shall be so designed and arranged as to make future extension of the switchboard readily feasible.

7.7.9 Interchange-ability

All corresponding components of the switchgear of same rating shall be fully interchangeable.

7.7.10 Dummy Panels

The Contractor shall automatically include dummy panels as and where required for bus duct / cable termination purpose/ PT's etc. Any ad-hoc arrangement such as extension chamber at the back or bottom shall not be accepted.

7.8 Equipment Details

7.8.1 Main Bus Bars

Aluminium Bus bars shall be provided. The Contractor shall furnish calculations establishing adequacy of bus bar sizes for specified current ratings/ fault levels. The size shall be of suitable size meeting the system requirements. The bus bar shall be having cast epoxy resin insulation around it having dielectric strength to withstand 12 kV rms.

Bus bars shall be located in air-insulated enclosures and segregated from all other compartments of the panel. Direct access or accidental contact with bus bars and primary connections shall not be possible. Inter panel bus bar barriers shall be provided and bus bars shall be taken through seal off bushings.

Bus bars shall be adequately supported and braced to withstand the thermal and electro-dynamic stresses arising due to short circuit currents as specified for the circuit breaker. Separate supports shall be provided for each bus bar.

Bus bar joints shall be bolted type and have adequate dielectric strength. Bus bars shall be thoroughly cleaned at front locations and suitable contact grease shall be applied just before making a joint.

The bus bar support insulators shall be porcelain/cast resin type.

Maximum temperature of the bus bars and links while carrying rated current under specified ambient condition shall not exceed the limits specified in IEC 60298.

7.9 Circuit Breakers

Circuit breakers shall be vacuum type and shall be horizontal draw-out type. A circuit breaker shall comprise of three separate identical single pole units operated through a common shaft by the operating mechanism.

Circuit breakers shall be suitable for making and breaking the specified fault current as well as normal currents from full load to no load currents.

The bidder shall provide suitable arrangement for easy withdrawal and insertion of breaker. The complete circuit breaker along with its operating mechanism shall be mounted on carriage supported by perfectly aligned ball bearings moving on guides designed to align correctly and facilitate easy and smooth movement. Both power and control disconnectors shall be robust, reliable and fully self-aligning. Separate draw out channels for taking out of the feeder from the cubicle shall not be accepted. Two nos. of roller for handling of circuit breaker in the switchgear room shall be supplied.

The circuit breaker shall have three distinct mechanical positions as follows and shall be provided with suitable handles for racking in/out of the circuit breaker.

- “Service” Both power and control contacts are connected.
- “Test” Power contacts are isolated, control contacts are connected.
- “Isolated” Both power and control contacts are isolated.

Locking facility shall be provided to block the circuit breaker in service or test position.

Operating Mechanism:

The closing mechanism of the circuit breaker shall be stored energy type and shall be simple and reliable in operation. The closing mechanism shall be provided with universal motor.

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

Operating mechanism shall be trip free and shall incorporate mechanical & electrical anti-pumping feature.

After the breaker is closed, the closing spring shall automatically get charged for the next closing operation immediately. Closing action of the breaker shall simultaneously charge the opening spring ready for tripping.

Mechanical indicator to indicate the charged and discharged condition of the spring shall be provided.

Circuit Breaker Control Devices:

The circuit breaker shall be suitable for remote electrical and local electrical/manual operation as well as control from SCADA. The incomer panel shall be closed from Synchronising panel. A lockable remote/local selector switch with indication lamps shall be provided for the purpose.

The circuit breakers shall be provided with control and selector switches for its operation (electrical). The control switches shall be three-position, spring return to neutral type provided with target to indicate the last operation of the switch. Adequate number of spare contacts shall be provided on the control switch for control, interlocking, annunciation and indication.

Shunt trip coils shall perform electrical tripping. The device shall be self-reset type and shall permit tripping and closing in service and test position.

"Red" and "Green" indication lamps shall be provided on the panel to indicate breaker "close" and "open" positions. In addition to above, mechanical indicator shall be provided which shall be clearly visible to the operator standing in front of the panel. Separate indication lamps for trip circuit healthy and auto trip condition of circuit breaker shall also be provided.

Suitable indication to show the circuit breaker in "service", "test" positions shall be provided. Suitable indication to show AC & DC control supply healthy shall be provided.

Direct acting mechanical closing and tripping devices shall be provided. The mechanical closing devices shall be approachable only after opening the breaker's compartment door and mechanical closing shall be possible in "test" and "isolated" positions only. In case the bidder considers it desirable to locate the mechanical tripping device on the compartment door for the purpose of emergency tripping, then the device shall be suitably designed/ shrouded to prevent inadvertent operation. However, right of acceptance of the same shall be with the purchaser.

Auxiliary Contacts:

Each circuit breaker shall have a minimum of 4 NO + 4 NC auxiliary contacts in addition to those required for breaker operation and annunciation. All auxiliary switches shall be adjustable either for "Normally open" or "Normally closed" position. The "NC" contacts shall break before main and auxiliary "NO" contacts make. All contacts shall be wired out to readily accessible terminal blocks.

In addition to above, the circuit breaker shall be provided with adequate number of wired out contacts for indication of service/test positions of the breaker on the control board.

The breaker operating mechanism shall preferably directly operate all auxiliary contacts.

7.9.1 Current Transformers

The current transformers shall have specified technical parameters and their thermal and dynamic ratings shall not be less than those of the associated circuit breakers. The CT's offered shall withstand the fault current till the fault clearing time with the backup protection of the respective breaker for the scheme of protection to be finalised with the contractor as per specification. The CT's shall be capable of withstanding the thermal and mechanical stresses developed under the above conditions.

CTs shall be of cast resin type and shall have polarity marks on each transformer and at its associated terminal block. Secondary circuits of the current transformers shall be earthed to main earth bus running at bottom of the panel separately.

The Contractor shall ensure that the current transformers for protection shall have adequate VA output for the type of protection offered. The Contractor shall also ensure that the current transformers quoted by him have adequate output for prescribed accuracy class and accuracy limit factor for the type of relays and instruments connected in their circuits. PS class CT's shall have low secondary resistance and high knee point voltage so as to avoid any possibility of CT saturation under through fault conditions.

The CT's shall be mounted in segregated chamber on the fixed position of the panel.

Auxiliary current transformers of suitable rating shall be provided in the panels wherever necessary.

The parameters of current transformers may undergo marginal modifications before final approval of Contractor's drawings but these changes shall not affect the total cost of the equipment. The current ammeter, kWh meter, kVAR meter, kVA meter and relays shall be provided in the front of the panel.

7.9.2 Voltage Transformers

VTs shall be of cast resin and draw-out type and shall be suitable for dual purpose of protection and measurement. The voltage transformers shall be provided with miniature circuit breakers on the secondary.

The VTs shall have at least three auxiliary draw-out contacts. These contacts shall open before the main draw-out contacts open and close after the main draw-out contact close.

The secondary circuits of each VT shall be earthed at only one place.

Three single phase voltage transformers shall be suitable for connecting in a bank of three phase voltage transformers for protection and measurement purpose for each bus section. The indication and

monitoring for the VT MCBs shall be available at UCB/SCADA. The voltmeter with selector switch shall be mounted in the front of panel.

7.9.3 Lightning Arresters

The lightning arresters shall be metal oxide gapless type and shall be suitable for indoor installation. The lightning arresters shall conform to IEC 60099-4. The arresters shall be suitable for specified parameters.

7.9.4 Cable Termination

Suitable single compression type, heavy duty brass cable glands with check nuts, rubber sealing ring and brass washers mounted on a removable gland plate shall be supplied with the switchgear to support all power and control cables entering the switchgear. Cable glands shall incorporate built in facility for earthing the armour of cable. Cable glands shall be tin-plated to avoid corrosion.

Cables to be terminated shall be 11 kV grade, XLPE, PVC sheathed and armoured. Power cables shall be of aluminium conductor and control cables 1100 V grade of copper, conforming to relevant IS.

Necessary cable boxes with crimping type tinned copper lugs shall be provided for power and control cables.

The cabling chamber shall be of adequate dimensions to accommodate creepage distances and stress cones involved in the case of termination of XLPE insulated, aluminium conductor armoured cables.

Cabling chamber shall be dust and vermin proof and properly gasketed to avoid ingress of moisture and dust.

7.9.5 Safety Interlocks and Features

With the circuit breaker in "closed" position it shall not be possible to withdraw its carriage from service position or to plug the carriage into service position. Attempted withdrawal of closed circuit breaker shall not trip the circuit breaker.

Operation of a circuit breaker shall not be possible unless its carriage is fully in service, test and isolated positions or has been taken out of the panel. Breaker operation shall be prevented in the intermediate positions.

It shall not be possible to open the breaker compartment door when the breaker is in "service" as well as in "test" position. Further, it shall also not be possible to rack in the breaker to "test" or "service" position if the compartment door is not properly closed. However, interlock to defeat this feature shall be provided.

Circuit-breaker/panel shall be provided with safety shutters operated automatically by the movement of circuit-breaker carriage to cover the stationary main contacts as soon as the breaker is withdrawn from service position. It shall, however, be possible to open the shutters intentionally against spring pressure for testing purposes.

The secondary contacts shall be of robust design and fully self-aligning and self-isolating type and the same shall get engaged before the main contacts have done so.

Interlocks shall be provided for blocking the entry of a carriage equipped with circuit breaker of one rating into a panel having stationary contacts of different rating.

7.9.6 Relays

Numeric microprocessor based protective relays shall be preferably mounted on the front of the cubicle enclosed in flush, dust tight, draw out cases finished with dull black enamel paint with self-contained test facilities and provision for removing relays mechanism for inspection and maintenance.

The relay shall be self-reset type tropicalized and their contacts shall be capable of making, carrying and breaking currents of the associated circuits. These contacts shall be silvered and shall have wiping action.

All relays shall be numeric type. The non-directional over current (3 phase) and ground fault relay with delayed and instantaneous functions shall be provided for station service transformer, Barrage & colony feeder. The transformer and generator incoming circuit breaker shall have the protection. The relays shall have IDMT, instantaneous, inverse, very inverse characteristics having over current (3 phase) with and earth fault current with suitable programmable plug/time setting. The relays shall have continuous monitoring and self-diagnostic features and shall have suitable indications.

The Restricted Earth Fault Relay shall be modular in construction. The relays shall be of high impedance, circulating current type and shall have suitable setting range. It shall be tuned to appropriate frequency to reject harmonics created by CT saturation and shall have suitable stabilising resistors for ensuring stability against external faults.

The under voltage relays shall be of single pole definite minimum time type and have an adjustable setting of 40 to 90% of the rated voltage. The relay shall have an adjustable /time delay setting range of 0.5 - 5 seconds and drop off to pick up ratio not higher than 105%.

High speed tripping relay and suitable auxiliary relays, fuse failure and supervision / monitoring relays shall be provided as per the Schedule of Requirements.

Any alternative protection scheme providing similar protection may also be quoted but the acceptance or rejection of the scheme finally lies with the purchaser.

7.9.7 Co-ordination of Protection

Complete calculations, protection scheme and curves demonstrating the selective co-ordination of the protective elements and recommended settings for the protective devices shall be furnished by this Contractor for approval during detailed engineering. This aspect shall be clearly confirmed by the bidder in his bid.

7.9.8 Instruments

The instruments shall be flush type and shall have dust-proof and moisture resistant black cases suitable for tropical use and conforming to latest issue of IS 722, Part 1. All indicating type instruments shall conform to IS 1248.

The accuracy class of indicating instruments shall be 1.0 or better to meet the functional requirements.

All instruments shall have means for calibration, testing and adjustment at Site. All elements shall be shock resistant and shall be shielded from external magnetic field.

Three phase watt-hour meters, kVAR meter, MW meter, frequency meter conforming to latest issue of IS 722, Part I & III or applicable standard, shall be suitable for use with the respective CT and VT ratios. Meters shall be compensated for temperature errors and factory calibrated to directly read the primary quantities. Multi-function meters having all the required measuring outputs as its inbuilt features shall also be acceptable.

7.9.9 Control Wiring

Control cables shall be 2.5/4.0 mm² size copper and shall enter from bottom for PTs and CTs. Terminals to be provided by Contractor in the cubicles for external connection shall be suitable for such sizes. All the cabling work up to UCB/ station control panels & synchronisation panel shall be carried out by the contractor.

All units shall be furnished completely factory wired up to terminal blocks ready for external connections. The control wiring carried out shall be of adequate cross-section and not less than 1mm² copper wire and the current transformer secondary wires shall not be less than 2.5/4 mm² copper.

All wires connecting the equipment's on the front to the internal portion of the cubicles shall have suitable flexible arrangements to facilitate frequent opening and closing of the door.

All wires shall have PVC insulation for 1100V and shall be suitable for switchboard wiring and comply with the requirements of IS 1554, Part I (latest issue). Each wire shall bear an identifying ferrule or tag at each end or connecting point.

All the operating coils and small wires shall withstand as erected, a power frequency test voltage of 3kV for one minute.

All outgoing control wiring, including that for connection between shipping sections shall terminate on terminal blocks preferably vertically mounted on the side of each cubicle. Suitable supports shall be provided for the incoming cables. The terminal blocks shall be arranged to provide maximum accessibility to all conductor terminations and any arrangement preventing ready access to other terminal screws will not be accepted.

All spare contacts of the relay and circuit breaker auxiliary contacts shall be supplied and wired up to the terminal block. Current transformers which are unused shall be wired up to the terminal blocks and short-circuited.

At least 20 nos. spare terminals shall be provided in each breaker feeder and VT feeder and shall be suitably distributed on the terminal block.

The terminal blocks shall be made of a moulded non-inflammable plastic material with bases and barriers moulded integrally. Each block shall have washer-head binding screws for external circuit wire connections, while marking strip for circuit identification and moulded plastic cover. All terminals shall be clearly marked with identification numbers or letters to facilitate connections to external wiring. All the indication, metering, monitoring & protection shall have provision for integration with SCADA system of the point

Terminal blocks shall include separate terminals for testing the relays, instruments and short-circuiting of the CTs if these facilities are not provided elsewhere in the manufacture's equipment. Not more than two wires shall be connected to any terminal. The terminals for CTs shall be of disconnecting type with automatic shorting of CT secondary terminals.

7.9.10 Control Supply Arrangement

Two suitable Miniature Circuit Breakers shall be furnished in every switchgear panel to receive two feeders of 110 V DC control supplies. A selector switch for selection of either of DC sources shall be provided.

The DC control power supply shall be tapped for each cubicle through separate MCB.

Secondary control and protection bus bar suitably located and running along with entire length of each switchgear board shall be preferred. In case inter panel looping is adopted for secondary control and protection; suitable arrangements shall be made inside the panels for this purpose. When a unit of switchgear comprises more than one shipping section, the Contractor shall furnish all materials and drawings required for the interconnections in the secondary bus bars during installation.

The bus bar/looping wires of copper shall be of adequate cross-section for their respective requirements. The schematic & cable schedule for complete panel shall be supplied by the contractor.

7.9.11 Earthing

A tinned copper earth bus of size not less than 50 x 6mm² shall be provided at the bottom and extend throughout the length of the switchgear. It shall be bolted / welded to the frame work of each unit and each breaker earthing contact bar. The earthing bus shall have adequate cross-sections and supports to withstand the specified short circuit current without exceeding maximum allowable temperature rise.

Circuit breaker trolley shall be equipped with a reliable and sturdy earthing mechanism. Positive earthing of circuit breaker shall be maintained when it is in the service position and in all other positions while the auxiliary circuits are not totally disconnected.

All metallic cases of relays, instruments and other panel mounted equipment's shall be connected to the earth bus by independent copper wires of size not less than 2.5mm². Earthing wires shall be connected on terminals with suitable clamp connectors and soldering shall not be permitted. Bolted joints, splices, tap, etc. to the earth bus shall be made with at least two bolts.

Suitable bolted connection for bolting the earth bus to earthing conductor shall be provided at each end of earth bus.

All non-current carrying metal work of the switchboard shall be effectively bonded to the earth bus.

Hinged doors shall be earthed through flexible earthing braid.

Looping of earth connectors which would result in loss of earth connection to other devices when the loop is broken shall not be permitted. However, looping of earth connections between equipment to provide alternative paths to earth bus shall be provided.

The neutral of CTs and VTs shall be earthed to each bus running at the bottom of panel separately so that earthing may be removed from one group without disturbing continuity of earthing system for other groups.

7.10 Tests

7.10.1 Type tests

All type tests shall be carried out in the manufacturer's works on the assembled switchgear and components as per relevant standard and type test reports shall be submitted to the purchaser for approval. The type test reports of similar or higher rating Switchgear shall be submitted during execution instead of conducting the tests shall also be acceptable.

7.10.2 Routine Tests

Each switchboard shall be assembled at the manufacturer's works with all the apparatus, instruments and meters connected up and the various components shall be tested in accordance with requirements of IEC 60298 and 62271-1 or any other relevant IEC/IS. The tests shall be performed in the presence of purchaser's representative. The following routine tests shall be included:

- Power frequency voltage dry tests of the main circuits.
- Voltage tests on control and auxiliary circuits.
- Measurement of the resistance of the main circuit.
- Mechanical operating tests wherever applicable.

7.10.3 Commissioning Tests

The following minimum commissioning checks / tests shall be carried out on the equipment at site as per standards.

Circuit Breaker:

- Insulation resistance of each pole of breaker.
- Anti- pumping operation.
- Minimum pick-up voltage of closing and tripping coils and operation at the highest permissible voltage.
- Contact resistance.
- Breaker closing and tripping time.
- Functional checking of control circuits, interlocking, tripping through protective relays, local/remote close/trip operation for breakers in service/test position.
- Correct operation of spring charging motors and spring charging time.
- Insulation resistance of control circuits.
- Total operating time and the total time for which the main contact remains closed when the simultaneous close and trip commands are given to the breaker.

CTs / VTs

- Insulation resistance test.
- Ratio and polarity.

Relays

- Calibration checking by secondary injection.
- Stability and continuity check by primary calibration.

Bus Bars

- Tightness test of bus bar joints.
- Inspection of insulators.

HV tests

- High voltage test shall be conducted at Site on completely installed switchboards. The high voltage (after application of high altitude correction factor) shall be applied to the bus bars and links. All external power connection shall be removed and the test voltage applied with all circuit breaker closed. The Contractor shall furnish complete test procedure, with list of tests, test values and test formats for approval during detailed engineering. The operational tests, dielectric tests, commissioning performance test shall be conducted at site.

7.11 Drawings, Documents and Design Calculations**7.11.1 Design memorandum**

The Contractor shall submit to Purchaser a design memorandum prepared in accordance with "Section 1-General Technical Specifications" of the proposed equipment /system fulfilling the contract specification/requirement for approval prior to submission of drawings and documents. The design memorandum shall include the design philosophy, methodology, system description, input parameters for design, standards and codes, design & selection criteria, equipment data, material specification, major technical features, basic arrangement / layout etc.

7.11.2 Drawings and documents

- Dimensional and OGA drawing of switchgear panels
- Foundation drawings of switchgear panels
- Descriptive and illustrative details of vacuum breakers, CTs, PTs, LAs etc
- Control schematics and interlocking scheme for switchgear
- Details of Floor cut outs for cable entry to panels
- Mounting details and disposition of the equipment mounted on the panels
- Cable entry details for incoming and outgoing feeders.
- Cable schedule.

- Wiring schematic diagram.
- Catalogue and manuals for relays.

7.11.3 Design calculation

The Contractor shall submit the design calculation in accordance with “General Technical Specification (GTS)” covering at least the following, for review / acceptance.

- Calculations for fixation of normal and short circuit current rating of Bus bars and cross sectional area of Bus bar conductor
- Calculations for determination of normal and short circuit current rating of generator incoming and generating step-up transformer feeders
- Calculations for selection of cable sizes
- Calculations for selection of bus bar conductor cross section.
- Temperature rise of bus bar conductor.

7.12 Delivery, Installation and Commissioning

The Contractor shall follow the requirements of Delivery, Installation and commissioning elaborated in clause 1.8 “packing and transportation”, clause 1.9 “site installation and erection” & clause 1.10 “site inspection & tests” of “Section 1 - General Technical Specification”

7.13 Spare Parts

The spare parts shall include the followings for supply:

i) Breaker fixed and moving contact -	1 set
ii) Numerical protective relays -	1 no. each type
iii) Breaker charging motors -	1 no.
iv) Closing coil -	2 nos.
v) Tripping coil -	2 nos.
vi) CT & PT -	1 set each

7.14 Special Tools

The Contractor shall propose the list of recommended special tools (other than those included under "Tools and Appliances" above) including their make and detailed specification as recommended by manufacturer(s) and to be accepted by the Purchaser.

7.15 Quality Assurance and Testing

The bidder shall submit the quality assurance plan along with bid for approval of the purchaser. The Contractor shall follow the quality assurance and testing requirements as per quality assurance plan approved by the purchaser.

7.16 Guaranteed and Technical Particulars

Guaranteed and Technical Particulars as called for in Vol. VI shall be furnished along with the bid. Bids lacking in this may be considered unresponsive. Particulars subject to guarantees shall be clearly marked.

7.17 Completeness of Equipment

All fittings and accessories of the 11kV indoor Switchgear and associated auxiliary & ancillary equipment which may not have been specifically mentioned in these specifications, but are usually necessary for completion of the above equipment, shall be deemed to be covered by the specification; and shall be indicated and furnished by the supplier without any charges to the purchaser.

7.18 Deviation from Specifications

While the purchaser does not bind himself to accept any deviation, due consideration will be given to any special devices or equipment put forward by the supplier with a view to increase the efficiency of the equipment and minimize the maintenance cost of the equipment as a whole.

Should the supplier wish to depart from these specifications, he shall submit a complete and itemized list of such deviations, together with full particulars of the reasons for the deviations in a separate schedule with special reference to clause and paragraph nos. of this specification. Unless this is done and also the purchaser's concurrence in respect of such deviations is obtained in writing, the equipment offered shall be deemed to comply in every respect with these specifications.