

VOLUME-2
PART- I
Section-16
132 kV Switchyard

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16. 132 kV Switchyard

16.1 Scope of Work

The intent of these specifications is to define and cover the scope of work under this section which covers the provision of design, manufacture, packing, forwarding, deliver at site, site storage, 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 of 132 kV Outdoor switchyard for Keyi Hydro Electric Project, Arunachal Pradesh, as per the specifications hereunder, complete with all auxiliaries, accessories, spare parts, any other items not specifically mentioned but required for the completion of facility and warranting a trouble free safe operation of the installation.

One number 132 kV switchyard bay for interconnecting bay at remote end is included in the scope of work as optional item and all the equipment, bus, structures, protection, earthing as required for the complete bay shall be included as OPTIONAL and price for the same shall be quoted accordingly.

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.

16.2 Scope of Supply

16.2.1 Main switchyard equipment

Main switchyard equipment such as circuit breakers, isolators, current transformers, potential transformers, bus PT, voltage transformers, lightning arrestors for the proposed 132kV outdoor switchyard & interconnection with powerhouse for the following bays:

- 2 (two) nos. unit feeder bays each comprising of one circuit breaker, two isolators with earth switch, lightning arrester, current transformer, etc.
- 1 (one) no. outgoing feeder bay to Zero substation comprising of one circuit breaker, two isolators with double earth switch, lightning arrester, current transformer, voltage transformer etc.
- Single bus arrangement.
- 1 (one) no. remote end bay at Zero substation comprising of one circuit breaker, two isolators with double earth switch, lightning arrester, current transformer, voltage transformer, support structures, protection, earthing etc. in complete (OPTIONAL ITEM).

16.2.2 Common items

The following common ancillary items & other essential equipment shall be in the scope of Contractor for the 132kV outdoor switchyard works:

- Switchyard steel structure including towers, beams, equipment support structures, lighting poles etc.
- ACSR panther conductors & earth wires, clamp & connectors (expansion or rigid type), post insulators, tension/suspension insulators & hardware, jumpering, vibration dampers, corona rings etc.
- Cables, cable trays, cable trench covers & support structures (included in the PTS of Cables & Accessories).
- Earthing & lightning system (included in the PTS of Grounding & Lightning System)
- Switchyard illumination (included in the PTS of Grounding & Lightning System)
- Switchyard automation (included in the PTS of SCADA system).
- Switchyard fire protection system (included in the PTS of Fire Protection System).
- Bay marshalling kiosks, AC & DC distribution boards etc.
- Items required for interconnection with powerhouse including support structures/gantry structures as applicable.
- Hume pipes, MS/GI pipes for cable laying from individual equipment to cable trenches, road crossing.

16.2.3 Common supplies

- Spare parts as per clause of "Spare Parts".
- Tools and instruments as per clause of "Tools and Instruments".
- Drawings, O&M manuals etc. as per "Drawings, documents and design calculation".

16.3 Codes and Standards

The equipment and system shall primarily conform to the latest applicable IEC/IEEE/BS standards: Some of the major applicable standards are mentioned below:

IEC: 62271-100	EHV Circuit Breakers
IEC: 376	Specification of Technical Grade Sulphur Hexafluoride (SF6) for use in Electrical Equipment
IEC 60273	Characteristics of Indoor and Outdoor Post Insulators for Systems with nominal voltages greater than 1000 V

IEC: 62271-102	Isolators and Earth-switches.
IEC-60044	Instrument Transformers
IEC137	Bushings for Alternating Voltages above 1000 V
IEC 60296	Insulating Oils for Transformer & Switchgear
IEC: 60185,	Current Transformers
IEC: 60233	Tests on Hollow Insulators for use in Electrical Equipment
IEC: 60044	Capacitive Voltage Transformers
IEC: 60186,	Voltage Transformers
IEC 60099	Gapless Surge arrestor.
IEC 60815	String Insulators discs
IEC Pub 120	Dimensions of ball and socket couplings for string insulator units
IEC Pub 438	Dimensions of clevis and tongue couplings for string insulator units-
IEC Pub 60437	Radio Interference Test on High Voltage Insulators.
IEC 60353	Wave-Traps
IEC 60870-5-101	Communication protocol for Substation
IEC 61850	Automation
IEC 60889	Hard Drawn Aluminium Wire for Overhead Line Conductors
IEC 61089	Standard Aluminium Conductor AAC Conductor ACSR Conductor
EN 755-2	Aluminium and Aluminium Alloys - Extruded Rod/Bar, Tube and Profiles
IEC60273	Clamps for Tubular Aluminium Conductors
BS 1490	Aluminium and Aluminium Alloy Ingots and Castings for General
BS159: 1957	Busbar and Busbar Connections- British Standards Institution

BS 3288: Insulator and Conductor Fittings for Overhead Power Lines: Part 1 Performance and General Requirements issued by British Standards institution (UK).

IEC 60364-5-54 Electrical Installations of Buildings- Selection and Erection of Electrical Equipment- Earthing Arrangements, Protective Conductors and Protective Bonding Conductors ASCE Manual No. 52 Guide for Design of Steel Transmission Line Towers - Issued by American Society of Civil Engineers (ASCE) New York, ASTM A-123: Spec. for Zinc (Hot Galvanized) Coatings on Products Fabricated from Rolled, Pressed and Forged Steel Shapes, Plates, Bars and Strips.

IEC: 60439 Low-Voltage Switchgear and Control Gear Assemblies

IEC: 60947 Low-Voltage Switchgear & Control Gear BSCP 3 Code of Basic Data for Design of Buildings: Chapter V Loading, Part 2 Wind loads.

ANSI A58.1 American Standard Building code Requirements for Minimum Design Loads in Buildings and other Structures.

BS-5950-2000 Structural Use of Steelwork in Buildings: Part 1 Code of Practice for Design in Simple and Continuous Construction: Hot Rolled Sections, British Standards Institution, London.

The electrical installation shall meet the requirements of Indian Grid Code as amended upto date. In addition, other rules and regulations applicable to the work shall be followed. Latest version of IEC shall be applicable even though the old version of IEC is mentioned above.

Equipment and material conforming to any other standard, which ensures equal or better quality, may be accepted subject to approval of the Owner. In such case, copies of the English version of the standards adopted shall have to be submitted along with the bid.

16.4 Reference drawings and documents & interfacing

- i) For layout of switchyard refer switchyard layout drawing
- ii) For schematic of protection and metering, refer relevant drawing.
- iii) For site-specific data such as, altitude, ambient temperature, humidity etc. and other technical requirement, refer General technical requirement.

16.5 Special design and layout condition

The layout and the design of the switchyard shall be such that:

- a) It shall have single busbar scheme.
- b) Adequate space for maintenance of prime equipment like circuit breakers, isolators and current transformers is available. Bus level above the approach road as indicated in layout drawing shall be so maintained that minimum sectional clearance is obtained for working personals with entry of a truck for maintenance of CB & Isolators.
- c) Approach road all around the switchyard shall also be provided for maintenance and patrolling by other Contractor.
- d) For cable trenches, drain, construction of switch room, roads, fencing, gates, civil foundation of equipment/structures & other civil works relevant input drawings shall be furnished by switchyard Contractor.
- e) The Conductor tensions shall be as indicated in the specifications of switchyard structure. However, the contractor shall have to carry out Sag-Tension calculations to ensure proper electrical clearances of the conductor. In case the same is not maintained with the specified tension, due measures shall be undertaken in the switchyard structure to achieve the same in respective bays.
- f) All tension insulator strings shall have double tension string arrangement for powerhouse interconnection.
- g) One bay marshalling kiosk shall be provided for each bay in 132kV switchyard suitable for AC/DC distribution.
- h) The connections from LAs to transformers shall be through shortest electrical distance.
- i) Cabling from respective bays shall be laid through respective bay cable trench. Necessary cables for control, protection, indication & interlocking shall be laid and terminated at switch room.

Intra plant Bus in the form of Optical Fibre cable shall be used to transfer the switchyard signals from the switch room to the central control room in order to minimise the numbers of cables to be laid between powerhouse control room and switchyard control room. Necessary arrangement shall be provided at both the ends in the control room as well as central control room.

- j) Receptacles of 100 A ratings shall be provided on the gantries of each bay or may be provided in the bay marshalling kiosks at suitable location for connection to welding sets/other emergency equipment. The receptacles shall be of industrial type and suitable for outdoor installation.
- k) Corona rings & corona bells shall be used wherever required and same shall be of non-magnetic material. The requirements regarding RIV and corona extinction voltage shall include terminal fittings.
- l) The switchyard shall be provided with suitable phase markers and danger plates.
- m) Necessary lightning Masts with lightning spike of copper materials shall be provided on the top of each tower for lightning protection.
- n) Necessary Lightning Arrestors shall be provided on HV side of generator step up transformers.
- o) Spacing between support post insulators for supporting of rigid & ACSR conductors shall be calculated as per IEC: 865. Wherever equipment are connected to bus by rigid conductors, the cantilever strength of the insulators of the equipment shall be minimum 800kg.
- p) The following auxiliary supply shall be available for use in the protection system.

AC supply 415V/230V (+/-10%), 50Hz (+/-5%) with +/-10% combined voltage and frequency variation.

DC supply 110V (+10/-15%)

16.6 Design Criteria

16.6.1 General

The HV Outdoor switchyard shall be designed to provide continuous evacuation of power from the generating plant units. The switchyard is the High Voltage link between the plant and the transmission network. The design of the switchyard shall take into account the capacity of the generating units connected in tandem, future requirement if specified. It shall also consider the necessary protection required for transmission lines, transformers and generating units.

16.6.2 Assumptions

The 132 kV system shall have a fault level of 31.5kA for 1 sec, highly pollution environment. Also, the capacity of the line and generators are suitable for using ACSR conductor. Underground earthing is achieved by MS rod/flat conductors. Also, the communication protocol at the plant end is compatible with that of the switchyard.

16.6.3 System Parameters

EHV equipment and system shall be designed to meet the following major technical parameters as brought out hereunder.

	Description of parameters	132 kV System
1.	Type	Outdoor
2.	Scheme	Single busbar
3.	No. of bays	3
4.	System operating voltage	132kV
5.	Highest system voltage	145kV
6.	Rated frequency	50Hz
7.	No. of phases	3
8.	Rated Insulation levels	
	Full wave impulse withstand Voltage (1.2/ 50 micro sec.)	± 650 kVp
	Across isolating distance	± 730 kVp
	Switching impulse withstand voltage (250 / 2500 micro sec.) dry and wet	
	One minute power frequency dry and wet withstand voltage (rms)	
	Between live terminal to earth	275kV
	Across isolating distance	365kV 105kV
9.	Corona extinction voltage	500 micro volt
10.	Max. radio interference voltage for frequency between 0.5 MHz and 2 MHz at 320kV rms for 400 kV system and	
	Description of parameters	
	156KV system for 220kV system & 92KV rms for 132KV system	
11.	Minimum creepage distance	25 mm/kV
12.	Min. Clearances	
	Phase to phase	1300 mm
	Phase to earth	1300 mm
	Sectional clearances	3500mm
	Ground clearance	

13.	Rated short circuit current for 1 sec duration	4600mm 31.5kA
	NOTE: Increased clearance would be applicable for installation above elevation of 1000m over and above the specified clearances as per IEC.	
14.	System neutral earthing	Effectively earthed
15.	Rated terminal load	Adequate to withstand 110kg static load as well as wind, seismic and short circuit forces without impairing reliability or current carrying capacity.
16.	Support structure height	Adequate so that lowest part of support insulator of equipment is minimum 2550 mm from plinth level.

16.7 Type and Rating of switchyard main equipment

16.7.1 Circuit Breakers

In addition to the technical parameters as specified in above system parameters, the circuit breaker shall have the following ratings:

Sl. No	Description	Value
i)	Rated voltage	132kV
ii)	Rated continuous current (A) at design ambient temperature.	800 minimum
iii)	Rated power frequency withstand voltage (kV rms)	275
iv)	1.2/50 micro sec. Rated Lightning impulse withstand voltage (kVp)	±650
v)	Rated short circuit current breaking capacity at rated voltage. (with percentage DC component as per IEC: 62271-100 corresponding to minimum opening time under operating conditions specified) (kA rms)	31.5
vi)	Symmetrical interrupting capability (kA rms)	31.5
vii)	Rated short circuit making current (kAp)	80

	a) Out of phase breaking current capacity (kA rms)	As per IEC
viii)	Rated operating duty	O-0.3sec-CO-3min-CO cycle for line breaker O-3min-CO-3 min-CO for unit breaker
ix)	Reclosing	Three phase auto reclosing
x)	First pole to clear factor	1.3
xi)	Rated line charging breaking current	As per IS: 62271
xii)	Rated out of phase breaking current	10 kA rms
xiii)	Rated line charging interrupting current at 90 deg. leading power factor angle (A rms)	As per IEC
xiv)	Design ambient temperature	30 deg. C
xv)	Temperature rise over the design ambient temperature	As per IEC: 62271-100 with altitude correction factor
xvi)	i) Total break time as per IEC (ms)	65
	ii) Rated break time as per IEC (ms)	60
xvii)	Total closing time (ms)	Not more than 150
xviii)	Operating mechanism or a combination of these	Pneumatic/ spring/ hydraulic
xix)	Max. Difference in the instants of closing/ opening of contacts (ms)	
xx)	i) Within a pole	2.5
xxi)	ii) Between poles	3.3
xxii)	iii) Between poles (closing)	5.0
xxiii)	Trip coil and closing Coil Voltage	110V DC with variation as specified
xxiv)	Trip coil	Two independent tripping circuits, valves, pressure switches and coils to be provided for connection to different set of relay. The circuits shall operate correctly under all operating conditions upto rated breaking capacity and at all values of supply voltage between 70% & 132% of rated supply voltage. However even at 50% of rated supply voltage the breaker shall be able to operate. Trip coil supervision to be provided in both open and close position.
xxv)	Closing coil	Shall operate correctly at all values of supply voltage between 85% and 110% of rated voltage.
xxvi)	Noise level at base and upto 50m (distance from base of breaker)	140 dB (Max.)

xxvii))	Auxiliary contacts	Besides requirements of specification, the bidder shall wire up 5NO+ 5NC contacts for future use of purchaser.
: xviii)	Operation	Shall have both local and remote operation of breaker with local/remote lockable selector switch and close and trip control switch/push buttons shall be provided in the breaker control cabinet.
xxix)	Pressure Switch Contacts	Shall have densimeter and pressure switch contacts suitable for direct use as
		permissive in closing and tripping circuits. Separate contacts to be used for each of tripping and closing circuits. Fail safe logic/schemes to be employed if multiplying relays used.
xxx)	Supply Voltage monitoring	DC supply voltage for all auxiliary circuit to be monitored. Provision to be made for remote annunciations and operation lockout in case of supply failure.
xxxi)	Safety aspect	Breaker position to be maintained on loss of operating media and/or quenching media pressure.

16.7.2 Isolators & earthing switches

In addition to the technical parameters as specified in clause no: 16.6.5 (system parameters), the isolators shall have the following ratings:

Sl. No	Description	132kV
i)	Rated continuous current (A) at design ambient temperature.	800
ii)	Rated power frequency withstand voltage (kV rms)	
iii)	Between live part to earth	275
iv)	1.2/50 micro sec. Rated Lightning impulse withstand voltage (kVp)	
v)	Between phases & phase to earth	±650
vi)	Across isolating distance	± 730
vii)	250/2500 micro sec. Rated switching impulse withstand voltage (kVp)	

viii)	Between phases & phase to earth	NA
ix)	Across isolating distance	NA
x)	Rated short circuit current withstand capacity at rated voltage for 1 second (kA rms).	31.5
xi)	Temperature rise over the design ambient temperature	As per I EC-694
xii)	Operating mechanism or a combination of these	Electrically/ mechanically gang operated
xiii)	Auxiliary supply	110V DC with variation as specified 415V, 3-phase; 230V, 1-phase AC with variation as specified.
xiv)	Auxiliary contacts	Besides requirements of specification, the bidder shall wire up 5NO+5NC contacts for future use of purchaser.
xv)	Operating time	12 seconds or less.
xvi)	No. of auxiliary contacts on each earthing switch	Besides requirement of this spec., the bidder shall wire up 3 NO + 3 NC to TBs (Reversible) for Purchaser's future use.

16.7.3 Current transformers, Voltage transformer (EMVT, CVT), Lightning arrestors

In addition to the technical parameters as specified in clause no: 16.6.5 (system parameters), the current transformers, voltage transformers (EMVT/CVT) & lightning arrestors shall have the following ratings:

Sl. No	Description	132kV
i)	Number of poles.	1
ii)	Full wave impulse withstand voltage (1.2/50 microsec.)	
	- Between line terminals and ground for CT & VT	± 650 kVp
	- For arrester housing	± 650 kVp
iii)	Switching impulse withstand voltage (250/ 2500 micro-second) dry and wet between line terminals and ground	
	- Between line terminals and ground for CT & VT	NA
	- For arrester housing	NA

iv)	One minute power frequency dry and wet withstand voltage between line terminals and ground	275 kV rms
	- Between line terminals and ground for CT & VT	275 kV rms
	- For arrester housing	275 kV rms
v)	Corona extinction voltage (minimum)	$\Delta_-, \Delta_-, \Delta_-$
vi)	Max. radio interference voltage (micro volts) for frequency between 0.5 MHz and 2 MHz at 266 kV rms	
	For CT, VT	500 micro Volt (at 92 kV rms)
	For LA	500 micro Volt (at 92 kV rms)
vii)	Maximum temperature rise over design ambient temperature	As per IEC:6044-1, IEC: 186
viii)	One minute power frequency withstand voltage sec. Terminal & earth	5 kV
ix)	Partial discharge	
	For CTs, VTs	Not exceeding 10 pc
	For arrester at 1.05 COV	Not exceeding 50 pc.

16.7.4 Lightning arrestors

In addition to the technical parameters as specified in clause no: 16.7.7 (system parameters) & 16.8.3, the lightning arrestors shall have the following ratings:

Sl. No	Description	Parameter Value
i)	Rated arrester voltage	102 kV
ii)	Nominal discharge current	10 kA of 8/20 microsecond wave.
iii)	Discharge current at which insulation coordination will be done	
iv)	Minimum discharge capability	5kJ/kV
v)	Continuous operating voltage at 50 deg. C	102 kV

vi)	Min. switching surge residual voltage (1kA)	^_ ^_ ^_
vii)	Max. switching surge residual voltage (1KA)	280kV
viii)	Max. residual voltage at	
	5 kA nominal discharge current	310 kVp
	10 kA nominal discharge current	330 kVp
	20 kA nominal discharge current	^_ ^_ ^_
	Steep fronted wave residual voltage at 10 kA	^_ ^_ ^_
ix)	Long duration discharge class	
x)	High current short duration test value (4/10 micro second wave)	80 kAp
xi)	Low current long duration test value (2000 micro sec)	As per IEC.
xii)	Pressure relief class	A

16.8 Specific Technical Requirements of Switchyard Equipment

16.8.1 General Requirements

132 kV outdoor switchyard shall employ a suitable switching scheme as specified in these specifications. All equipment under these specifications shall be designed, manufactured, tested, and certified in accordance with the quality assurance requirements of the IEC Standards as a minimum requirement.

16.8.2 Circuit Breakers

a) Type

Outdoor SF6, single pressure, live or dead tank re-strike free and without opening resistors.

b) Duty Requirement

145 kV circuit breakers offered would be of sulphur hexafluoride (SF6) type only and of class C1-M1 as per IEC.

The circuit breaker shall be restrike free as per IEC under all duty conditions and shall be capable of performing their duties without opening resistors.

The circuit breaker shall meet the duty requirement for any type of fault or fault location also for line switching when used on a 145 kV effectively grounded system, and perform make and break operations as per the stipulated duty cycles satisfactorily.

The circuit breaker shall be suitable for interrupting line charging current and cable charging current as per IEC without any restrikes and without any closing resistors.

The breaker shall be suitable for charging 132kV line of length 15kms approximately, switching the inductive charging current of generator transformer, interconnecting transformers.

Withstand electromagnetic forces and stresses arising out of maximum peak asymmetric current of the circuit as well as load rejection and re-energisation of lines with trapped charges.

Circuit breaker's operating mechanism shall be suitable for 3-pole auto reclosure.

The total break time of the breaker (as per IEC) shall not be exceeded under any duty conditions specified inside the limits of the operating conditions such as trip coil voltage variation, pneumatic/hydraulic pressure or SF6 gas pressure.

c) Total Break Time

The total break time as specified under this Chapter shall not be exceeded under any of the following duties:

- i) Test duties 1,2,3,4,5 (TRV as per IEC: 62271-100)
- ii) Short line fault L75, L90 -do-

The bidder may please note that total break time of the breaker shall not be exceeded under any duty conditions specified such as with the combine variation of the trip coil voltage, (70-110%), pneumatic/hydraulic pressure and are extinguishing medium pressure etc. While furnishing the proof of the total break time of complete circuit breaker, the Bidders may specifically bring out the effect of non-simultaneity between contacts within a pole or between poles and show how it is covered in the guaranteed total break time.

d) Constructional Features

Interrupter assembly shall be with adsorbing product box to minimize the effect of SF6 decomposing product and moisture. SF6 Density shall be monitored and regulated on each pole using individual pressure switches and pressure gauges. Density Monitor shall be adequately temperature compensated.

It shall be possible to dismantle the monitor without draining SF6 gas & also to remove SF6 gas from each pose separately from maintenance purpose. Dual DC supply shall be provided for connection to independent trip circuits, monitoring & control circuits.

Aux. Switch of breaker to be positively driven by operating Rod.

e) Central Control Cabinet

A central control cabinet shall be provided which shall house all the control equipment required for operation, indication, lockout and all requirements as per detailed list given below:

- i) Local/remote changeover switch.
- ii) Local electrical operation.
- iii) Local manual operation in absence of DC supply.
- iv) Emergency trip push button with protective cover.

- v) Circuit breaker, mechanical ON/OFF position indicator.
- vi) Circuit breaker, ON/OFF position signalling device for remote indication.
- vii) Shunt trip device.
- viii) A heating element complete with a weatherproof rotary switch and thermostat.
- ix) Power plug/light point.
- x) Operation counter.
- xi) Pneumatic/hydraulic pressure gauges.
- xii) SF6 pressure gauges.
- xiii) Power supply control switches.
- xiv) Fuses.
- xv) Anti-pumping relay.
- xvi) Pole discrepancy relays.
- xvii) AC/DC supervision relays.
- xviii) Trip coil supervision relays.
- f) Sulphur Hexa Fluoride Gas (SF6 Gas):
 - i) The SF6 gas shall comply with IEF-376, 376A and 376B and shall be suitable in all respects for use in the switchgear under the operating conditions.
 - ii) The high pressure cylinders in which the SF6 gas is shipped and stored at site shall comply with requirements of the relevant standards and regulations.
 - iii) Test: SF6 gas shall be tested for purity, dew point, air, hydrolysable fluorides and water content as per IEC 376, 376A, 376B and test certificates shall be furnished to Owner indicating all the tests as per IEC 376.
- g) Operating Mechanism and Control.

Pneumatic / Electro-hydraulic / spring charged or combination of these with Anti-pumping and trip free features. Operating box/cabinet shall be accessible to man standing on ground and shall be hot dip galvanized. A mechanical indicator to show open/close position of breaker shall be provided which should be visible with housing closed.

Dual AC power supply with changeover facility shall be provided.

- h) Bushing and Insulators

The basic insulation level of the insulating porcelains shall be as per relevant IEC Standard. The porcelains used shall be homogeneous and free from cavities or other flaws. They shall be designed to

have ample insulation, mechanical strength and rigidity for satisfactory operation under conditions specified above. All insulators of identical ratings shall be interchangeable. The puncture strength of the insulators shall be greater than the flash over value. The insulators shall be entirely free from radio disturbance when operating at a voltage up to 10% above rated voltage and shall also be free from internal and external corona.

i) Pole Discrepancy Device

Should one or two poles of any breaker fail to open/close simultaneously with the other, a pole discrepancy protective device should ensure that all the three poles open/close simultaneously.

j) Pneumatically operated mechanism:

(i) Unit compressed air system housed in a separate dust and waterproof cabinet.

(ii) Air receiver sized for at least 2CO operations of breaker at the pressure gauges.

(iii) Air compressors of air-cooled type, rated for total running time of 45 minutes/day. The air charging time after one CO operation is maximum 20 minutes.

(iv) Adjustable pressure switches provided with potential free, ungrounded contacts.

(v) Piping using bright annealed, stainless steel or seamless phosphorous deoxidised non-arsenic copper alloy and shall be suitably supported at regular intervals. All joints shall be brazed or flared type.

(vi) Safety, stop non-return and other control valves.

(vii) Shall operate at air pressure limits of 85% to 110% of rated pressure. At these limits the specified make/break times shall be met.

(viii) The compressor shall be automatic start - stop type. Manual control shall also be provided.

(ix) Pressure lockout device to be provided with remote alarm indication for trip lockout for both coils, close lockout and auto re-close lockout.

k) Spring Operated Mechanism

(i) Shall be complete with motor, opening and closing spring with limit switch for automatic charging and shall generally meet all the design and operation requirements for satisfactory and trouble free operation.

(ii) Motor shall be rated to fully charge the closing springs in less than 30 seconds and shall have adequate thermal rating for repeated sequence of closing and opening operation.

(iii) Closing action of mechanism shall compress/charge the opening spring so that it is ready for tripping. Closing springs shall be immediately charged after the closing operation. After failure of power supply, at easy one CO operation should be possible. Breaker operation shall be prevented when spring is in partial charged condition. Indication of spring in charged condition shall be provided in local and remote cabinet.

l) Hydraulically Operated Mechanism

(i) Shall comprise of power cylinder, control valves, high & low-pressure reservoir, motor etc. Hydraulic oil used shall be fully compatible for the specified temperature range. Further it shall generally meet all the design and operation requirements for satisfactory and trouble free operation.

(ii) On failure of power supply and pressure equally to the lowest pressure of auto-reclose duty, at least two CO operations should be possible. Also complete duty cycle of breaker to be possible meeting all parameters of break/opening time when oil is at lowest permissible pressure before make up.

(iii) Provision to be made to continuously monitor oil/nitrogen pressure both local and remote.

(iv) One hand operated pump shall be provided per station for emergency operation.

m) Other Provisions:

The gap between open contacts shall withstand at least rated phase to ground voltage for eight (8) hours at zero gauge pressure of SF6 gas. The breaker shall also withstand all dielectric stresses in open position at SF6 lockout pressure for 60 minutes. Multi-breakers shall have provision for attaching operational analyser. Breakers shall have provision for attaching operational analyser.

Contractor shall supply spare SF6 gas equal to 20% of total requirement for the station.

16.8.3 Isolators and Earthing Switches**a) Type**

The 132 kV isolators shall be horizontal double break, central rotating turn twist type, gang operated, and outdoor type suitable for climatic conditions prevailing at Site. The blades of the isolator shall open or close in horizontal plane. Each three pole isolator shall consist of three identical single pole units linked together mechanically/electrically and shall be gang operated. The blades of earthing switches shall open or close in vertical plan. All isolators and earthing switches shall operate through 90° from their fully closed position so that the break is distinct and clearly visible from the ground level.

The bus sectionalising isolators shall be under hung type to be mounted on switchyard structures. The operating mechanism shall be mounted on the switchyard structure at a suitable height. The isolators shall be motor as well as manually operated. Earthing switches shall be manually operated only. Each earthing switch shall consist of three earthing links mechanically coupled to an operating shaft suitable for manual operation.

The isolators are not required to operate under load conditions but they may be called upon to handle magnetising currents of power transformers, capacitive currents of bushings, bus bar connections, short length of cables, etc.

The earthing switches shall be capable of discharging trapped charges of the associated lines. Isolator and earth switches shall be able to bear on the terminals, the total forces including wind loading and electro-dynamic forces on the attached conductor without impairing reliability or current carrying capacity.

The ground clearance to the nearest part of an insulator supporting live conductor shall be 2500mm.

b) Design

The design of horizontal break isolators shall be such that the isolator may be adopted in the field in upright or under hung mounting or it can be changed to right or left hand control without excessive labour and with minimum replacement of parts. Live parts shall be designed as far as possible to eliminate sharp points, edges and other corona producing surfaces. Factory adjustments shall be so made on each pole so that field changes will not be required on the switches.

All isolators shall have heavy duty self-aligning high pressure type fixed contacts being of modern design and made of hard drawn electrolytic copper. The thickness of silver plating shall preferably be not less than 25 microns. The male and female contact assemblies shall be of such construction and design that these shall ensure:

- i) Electro-dynamic with stand ability during short circuits without any risk of repulsion of contacts.
- ii) Thermal withstand ability during short circuits.
- iii) Constant contact pressure even when the live parts of the insulator stacks are subjected to tensile stresses due to linear expansion of connected bus bars or flexible conductors either because of temperature variations or strong wind.
- iv) Wiping action during opening and closing.
- v) Self-alignment during closing of the switch without minute adjustments.

All movable parts which may be in current paths shall be shunted by flexible copper braids. The conductors shall have sufficient length to prevent breaking.

The temperature rise of contacts and other current carrying parts shall not be more than the specified temperature rise and corrected for higher altitude as per latest issue of relevant IEC standard. The temperature rise due to the passage of the rated short circuit current shall not cause any annealing or welding of the contacts.

Live metal parts except insulator caps and base shall be of non-rusting, non-corroding metal. Current carrying parts shall be of non-ferrous material. Screws and pins shall be provided with lock washers, or equivalent facility.

The isolator shall be designed such that no lubrication of any part is required except at very infrequent interval is after every 1000 operations or after 5 years whichever is earlier.

c) Isolator and Isolator-Cum-Earthing Switch Operation

All isolators and earthing switches shall have separate dependent operation. The isolator shall be double break type. They should be provided with ON and OFF indicators and padlocking arrangements for locking in both the end positions to avoid unintentional operation. The isolating distance should also be visible for isolators and isolator-cum-earthing switches. The isolators and isolator-cum-earthing switches inclusive of their operating mechanism should be such that they cannot come out of their open or closed positions by gravity, wind pressure, vibrations, reasonable shocks, or accidental touching of connecting rods of the operating mechanism. The isolators and isolator-cum-earthing switches should be capable of resisting in closed position, the dynamic and thermal effects of maximum possible short circuit current at the installation point.

They shall be so constructed that they do not open under influence of the short circuit current.

The operating mechanism should be of robust construction, easy to operate by a single person and conveniently located for local operation in the Switchyard.

d) Operating Mechanism

The isolators shall be arranged for motor operation. Limit switches for control shall be fitted on isolator shaft within the cabinet to sense the open and close positions of the isolators. A local /remote selector switch and a set of open/close push buttons shall be provided on the control cabinet of the isolator to permit its operation through local or remote push buttons. Remote control switches and indicators will be supplied by the control panel Contractors and are not included in the scope of the specifications. The local control and local/remote selector switch shall, however, be provided with the isolators.

Each rotating insulator stack shall have double roller or double ball bearings at the base and roller or ball bearings at the other end. Provision should be made at or near the operating handles of all the switches for locking them in either the open or closed position. Additional electromagnetic type interlock shall be provided on the manual operating handle and control cubicle for motorised operation so as to prevent the operation of the isolator manually or electrically when the corresponding circuit breaker is closed.

The roller and ball bearing shall be adjustable and accessible for dismantling in the field. Bearing housings shall be weather-proof. A position indicator shall be provided at or near the operating mechanism for indication of the open and closed position of the isolator and earthing switch. The isolator and earthing switch shall have remote indication in the control room.

The vertical operating shaft shall be supported on ball or roller thrust bearings. Guide bearing shall be provided on the vertical shaft. The operating handle shall be designed for mounting on the base supported column at a convenient working distance above ground.

Motor operated mechanism suitable for operation on 3 phase 415 V or 1 phase 230 V, 50 Hz AC supply shall be provided to facilitate remote control of isolators and shall comprise of motor, starter, necessary control gear, limit switches and position indicators, etc.

The motor mechanism shall be suitable for vertical mounting on the steel framework of the isolator supporting structure at a suitable level, and shall be enclosed in a weather proof, vermin-proof, steel enclosures. The cover or access doors shall be of heavy gauge sheet. All steel parts shall be double hot-dip galvanised.

e) Earthing Switches

The disconnecting isolators controlling the transmission lines shall be equipped with grounding blades. The grounding blades shall be manually gang operated in a manner similar to the main blades.

Line earthing switches shall consist of three earthing links per isolator, which will normally rest against the frame, when the connected isolator is in closed position. The earthing links for the three phases shall be mechanically linked to a coupling shaft, which shall be capable of being fitted on either side of the isolator. Each earthing switch shall be mechanically and electrically inter-locked with the connected isolating switches.

The earthing switch shall be capable of discharging trapped charges of the associated lines.

The earthing switch shall be only locally operated.

f) Insulating Supports

Insulation to ground, insulation between open contacts and insulation between phases of the completely assembled isolating switch shall be capable of withstanding the specified dielectric test voltages. Insulation between open contacts of a pole shall be at least 15% more than the insulation between the live parts of a pole to ground so that if any flash over occurs when the isolator is open; it shall be directed to the ground. The post insulators shall conform to latest issue of IEC 168..

g) Interlocking Gear

All isolators and earthing switches shall be provided with the interlocking features specified below. All mechanical interlocks shall be designed to prevent mal-operation at the point at which hand power is applied and also that stresses cannot be applied to parts remote from that point.

All electrical interlocks shall so function as to interrupt the operating supply and an approved system of interlocks shall be provided when apparatus which is normally operated electrically is hand-operated. Failure of supply or connections to any electrical interlock shall not produce or permit faulty operation. The interlocking gear shall operate satisfactorily at 85% to 110% of rated auxiliary supply voltage.

h) Padlocks

Padlocks or other approved locking arrangement shall be provided for locking each isolator and earth switch operating handle in the ON and OFF positions and for locking each cover or door in the closed position. All padlocks shall be of approved size and two ordinary keys for each type of padlock shall be provided. In addition, master key for the same shall be furnished.

i) Cable Boxes

Cable boxes including cable glands for terminating multi-core control cables and power cables shall be provided wherever required. Necessary connecting materials for mounting of cable boxes on isolator structures shall be mounted in accessible position clear of the floor level to make the jointing work easy.

j) Terminal Connectors

The isolators shall be supplied with all Bi-metallic type terminal connectors suitable for single panther conductor for 132 kV bays. Suitable terminal connectors for earth connection to isolators at two points through 75 x 8 mm² steel flat shall also be supplied.

k) Galvanising

All ferrous parts except springs but including mechanism, housing shall be hot dip galvanised in accordance with latest relevant standard.

l) Name and Rating Plates

Each isolator and isolator-cum-earthing switch shall have non-corrosive name and rating plates legibly and indelibly marked in English and securely attached to it. These shall be provided with information as per normal practice and shall include among other things, the name of manufacture, type of isolator or isolator-cum-earthing switch, rated voltage, etc.

16.8.4 Current Transformers

a) Type

The current transformers shall be of outdoor type, single phase, 50 Hz, oil immersed, self-cooled and suitable for operation under climatic conditions prevailing at Site without any protection from sun, rain and dust.

b) General Requirements

For current transformers open circuiting of secondary on load causes very high peak voltage which may exceed the insulation level of secondary circuit and can damage insulation. It is therefore suggested that some form of CT secondary circuit protection be provided for various cores of the CT's. Such protection should be able to detect open circuit and act in the following manner.

- i) Short circuit the terminals of secondary windings in question or limit the voltage to safe level.
- ii) Provide a contact for annunciating this condition. This device shall not, however, mal-operate during actual fault conditions and should therefore be capable of being set accordingly. Also, the device shall be located as close to the CT Terminals as physically possible.

Current transformer characteristics shall be such as to provide satisfactory performance for burdens ranging from 25% to 100% of rated burden over a range of 10% to 100% of rated current in case of metering CT's and up to the accuracy limit factor/knee point voltage in case of relaying CT's.

All current transformers shall be provided with two terminal studs per pole. Expansion chamber at the top of the porcelain insulator should be suitable for expansion of oil and have provision for primary terminals.

c) Design and Construction

General-

The current transformers shall be single phase; oil immersed and self-cooled type, suitable for the services indicated and conforming to the best modern practice of design and manufacture.

Core-

The cores for the CT's shall be of high grade non-ageing cold rolled, grain oriented silicon steel of low hysteresis loss and high permeability to ensure high accuracy at both normal and over currents. The cores to be used for metering and indicating instruments shall have instrument security factor at all ratios less than five so as not to cause any damage to meters and instruments in the event of maximum short circuit currents. The cores to be used for phase comparison, distance, over current, earth fault and bus bar protections shall produce undistorted secondary current under transient conditions at all ratios with specified CT parameters specified in Table I. Magnetisation curves of these cores shall be furnished with the tender.

Windings-

Primary winding of current transformers shall have single primary windings ring type or hair pin type and shall be suitably insulated so as to have high electrical withstand properties and good ageing

qualities. The current transformers shall be of suitable construction at the bottom for bringing out secondary terminals.

The secondary terminal shall be brought out in a weatherproof compartment having degree of protection of IP55 for easy access. The secondary terminals shall be provided with shorting arrangements. The secondary tap shall be adequately reinforced to withstand the normal handling without damage. Different ratios specified shall be achieved by secondary taps only and primary reconnection shall not be accepted. The winding shall be designed to carry 120% of the rated primary current continuously. The current transformers' guaranteed burdens and accuracy class are intended to be simultaneous for all cores.

Bushings/Insulators-

The current transformer shall be provided with 145 kV class oil filled, shredded porcelain bushings/insulators suitable for outdoor service. The bushings/ insulators shall be one piece without any metallic flange joint. The bushing/ insulator shall have cantilever strength of not less than 350 kg.

Oil Level Gauge-

An oil level gauge shall be provided to indicate the oil level in the current transformer.

Pressure Relieving Device-

Each current transformer shall be provided with a pressure-relieving device so as to prevent bursting of current transformer even under unfavourable conditions.

d) Insulating Oil

The quantity of oil for first filling of each CT shall be stated. The oil shall conform to latest issue of IEC: 60296 - Specification of Unused Mineral Insulating Oils for Transformer & Switchgear.

e) Terminal Box and Junction Box

All secondary terminals shall be brought out in a weather proof (IP55) compartment on the side of each current transformer. These secondary terminals shall be terminated to stud type non-disconnecting terminal blocks inside the terminal box. The terminal board shall have arrangements for short circuiting of secondary terminals.

f) Galvanising

Current transformers along with top metallic shall be hot dip galvanised or painted with approved shade.

g) Mountings

The current transformers shall be supplied with suitable clamps, nuts, bolts and washers for mounting them on the steel structures.

16.8.5 Voltage Transformers

i) Type and Rating

The voltage transformers shall be single phase, 50 Hz, oil immersed, self-cooled, electromagnetic/capacitor type suitable for outdoor duty, operation without any protection from sun, rain and dust.

ii) Design and Construction

Electromagnetic Voltage Transformer

The core shall be of high grade, non-ageing, electrical silicon laminated steel of low hysteresis loss and high permeability to ensure high accuracy at both normal and over voltages.

Each voltage transformer shall have separate secondary winding for protection, residual voltage and metering. The primary of voltage transformers will be connected in "star" with the neutral point solidly earthed. The neutral of the system is also earthed. The secondaries of the voltage transformers for protection and metering shall be suitable for connection in 'star' and that for residual voltage connection shall be suitable for connection in open delta.

Oil filled condenser type porcelain bushings shall be used on the voltage transformers. The porcelain shall be homogenous, thoroughly vitrified, tough and impervious to moisture. The glazing of porcelain shall be of uniform brown colour, free from blisters, burns and other similar defects. The bushings shall have ample insulation, mechanical strength and rigidity for the conditions under which they will be used and shall be designed to prevent accumulation of explosive gases and to provide adequate oil circulation to remove internal heat. There shall be no undue stressing of any part of the bushings due to the temperature changes and adequate means shall be provided to accommodate conductor expansion. Each of the bushings shall be complete with the following fittings:

- i) Bimetallic expansion type terminal connector.
- ii) Oil level sight gauge and convenient means of filling, sampling, and draining of oil.
- iii) End shields for even distribution of stresses.
- iv) Corona shields for bushings, if required.
- v) Pressure relieving device.

All iron parts shall be hot dip galvanised or painted as per shade approved by the Purchaser. Each voltage transformers shall be hermetically sealed. Details of sealing shall be furnished in the Tender.

i) Insulating Oil

Insulating oil used for electromagnetic voltage transformers shall conform to IEC: 60296 or other equivalent standard for Insulating Oil. The quantity of oil required for first filling shall be stated.

ii) Pressure Relieving Device

Each voltage transformer shall be provided with a pressure-relieving device capable of releasing abnormal internal pressure.

iii) Terminal and Junction Box

The secondary terminals of the electromagnetic VT/CVT shall be terminated to the stud type non-disconnecting terminal blocks in the individual phase secondary boxes via fuse.

The terminal box shall be outdoor type, vermin proof and shall be provided with degree of protection of not less than IP55 as per IEC60529. The terminal box shall be provided with a easily detachable cover.

In addition to terminal box on each voltage transformer, Contractor shall also supply a common junction box for each set of three voltage transformers of each circuit. The junction box shall be weatherproof type, having a degree of protection of IP55. The junction box shall be suitable for mounting on the steel structure which shall be included in the scope of Tender. Sufficient number of terminals shall be provided in the junction box for connecting the leads from individual voltage transformers for formation of star and open delta connections. In addition to above sufficient no. of terminals (not less than 18) shall be provided for the Purchaser's use. The terminal connectors shall be suitable for connections with 4mm² multi-core copper control cables.

iv) Temperature Rise

Voltage transformers shall be capable of carrying their rated burden continuously at rated voltage and frequency without the temperature rise exceeding the limits laid down in the IEC standard and corrected to site condition for higher altitude. The temperature rise at 1.2 times rated primary voltage when applied continuously at rated frequency and at rated burden shall not exceed the limits specified in the standard and the temperature rise at 1.5 times rated primary voltage when applied for 30 seconds starting from previous stable operation condition at 1.2 times rated continuous voltage and rated frequency and burden shall not exceed the temperature limits by more than 10°C.

16.8.6 Lightning Arrestors

i) Type

The arresters shall be of modern design suitable for outdoor installation. The lightning arresters shall be of metal oxide gapless type without any series or shunt gaps. The lightning arresters shall be designed to provide maximum possible protection against lightning and switching surges.

ii) Detailed Description of the Equipment

The gapless lightning arrester shall consist of non-linear blocks of sintered metal oxide material stacked in series. These shall be provided in such a way as to obtain robust construction with excellent mechanical and electrical properties even after repeated operations. The arresters shall be of single column type.

The lightning arresters shall be fitted with pressure relief devices suitable for preventing shattering of porcelain housing and providing path for flow of rated fault currents in the event of arrester failure. The reference current of the arresters shall be high enough to eliminate the influences of grading and stray capacitance on the measured reference voltage. The tenderer shall furnish the values and supporting calculations along with the tender.

The arresters shall be of hermetically sealed units. Seals shall be provided in such a way that these are always effectively maintained even when discharging rated lightning current. The hermetic seals shall be stable during the lifetime of the arrester under the severe conditions expected.

Porcelain housing shall be so co-ordinated that external flashover will not occur due to application of any impulse or switching lightning voltage up to the maximum design value of the arrester.

The end fittings shall be made of corrosion proof material and shall preferably be non-magnetic.

The lightning arrester shall have adequate thermal discharge capacity for steep current lightning, switching lightning, long duration lightning and multiple lightning strokes. The arresters shall be of line discharge class 3 and shall be capable of discharging energy equivalent to the specified class on two successive operations.

iii) Surge Counters

Self-contained discharge counter suitably enclosed for outdoor use and requiring no. auxiliary or battery supply for operation shall be provided for each single pole unit along with necessary connection. Suitable leakage current meter shall also be supplied within the same enclosure having degree of protection IP 55. The reading of milli-ammeter and counter shall be visible through an inspection glass panel. The terminals shall be robust and of adequate size and shall be so located that incoming and outgoing connections are made with minimum possible bends. The design of the surge monitor shall be such that it is possible to tilt the surge monitor downwards by an angle of up to 45 degree from horizontal plane.

Surge monitor consisting of discharge counter and milli-ammeters shall be suitable for mounting on the supporting structure of the arrester. All nuts, bolts, washers etc. required for fixing the surge monitor shall be supplied by the arrester manufacturer.

iv) Equipment to be Protected and Impulse Levels

The lightning arresters are to be used for protection against lightning and switching surges for 132 kV transformers, circuit breakers, isolators, instrument transformer and other switchyard equipments.

The overhead lines are protected, by overhead earth-wires from direct lightning strokes.

The surge arresters are being provided to protect the following equipment whose insulation levels are indicated in the table given below: -

Equipment to be protected	Lightning impulse (k Vp) for 132kV system
Power transformer	±650
Instrument Transformer	±650
Reactor	
CB/Isolator Phase to ground	±650
Across Open contacts	±730

v) Porcelain Housing

All porcelain used in or with each arrester manufactured by wet process shall be homogeneous and free from lamination cavities or other flaws affecting the mechanical or dielectric strength and shall be vitrified and non-porous. The leakage distance along the external surface shall be long enough to ensure that surface contamination will not adversely affect the arrester performance characteristics.

vi) Pressure Relief Devices

The arrester shall be provided with efficient pressure relief devices conforming to class A as per IEC 99-1. The pressure relief device shall positively prevent the bursting of the arrester in case excessive gas pressure builds up in the event of failure of the arrester. The tenderer shall enclose detailed information and literature on the pressure relief devices.

vii) Gaskets

Metal parts at top and bottom of each porcelain unit shall be provided with necessary water tight gaskets.

viii) Galvanising

All metal parts, which are exposed to weather and are likely to be subjected to corrosion shall be hot dip galvanised as per latest IEC Standard.

16.8.7 Ancillary Items**a) ACSR Conductor**

Main Bus and Line Entry Conductor-

The conductor used shall be single panther for 132 kV bays. The standard ACSR conductor shall have multi strand of hard drawn aluminium/ galvanised steel wire. The manufacturer of the conductors shall conform strictly to the requirements of the latest edition of IEC61089 or its equivalent.

Constructional Features-

Materials Aluminium

The aluminium strands shall be hard drawn from electrolytic aluminium rods having purity not less than 99.5% and a copper content not exceeding 0.04%.

Steel-

The steel wire strands shall be drawn from high carbon steel wire rods and shall conform to the following chemical composition:

Element % Composition 0.50 to 0.85

Carbon 0.50 to 1.10

Manganese Not more than 0.035

Phosphorous Not more than 0.045 0.10 to 0.35

Sulphur Silicon Zinc

The zinc used for galvanising shall be electrolytic High Grade Zinc of 99.95% purity. It shall conform to and satisfy all the requirements of IS: 209 -1979.

Joints-

No joint shall be permitted in the aluminium wires in the outer most layer of the ACSR conductors. The joints for connecting individual wires of aluminium conductor shall be made by cold pressure butt-welding.

The joints for connecting individual wires of the steel core shall be made by resistance butt-welding or brazing and shall be protected against corrosion.

The joints for both aluminium and steel wires shall be so constructed that no air space is left within them. Their conductivity shall be such that a joined conductor shall have conductivity not less than an equal length of the conductor without joint. The tensile strength of the joints shall not be less than 95% of that of the conductors themselves. Full details with dimensioned scales and cross section of the joints offered shall be submitted with the tender.

b) String Insulators and Hardware

Constructional Features-

Suspension and tension insulators shall be manufactured by wet process porcelain with ball and socket connections. Insulators shall be interchangeable and shall be suitable for forming either suspension or strain strings. Porcelain used in insulator manufacture shall be homogeneous, free from laminations, cavities and other flaws or imperfections that might affect the mechanical or dielectric quality and shall be thoroughly vitrified, tough and impervious to moisture. Glazing of the porcelain shall be uniform brown colour, free from blisters, blurs and other similar defects.

When operating at normal rated voltage there shall be no electric discharge between conductor and insulator, which would cause corrosion or injury to conductors or insulators by the formation of substances due to chemical action. No radio interference shall be caused when operating at normal rated voltage.

The design of the insulators shall be such that stresses due to expansion and contraction in any part of the insulator shall not lead to deterioration. All ferrous parts shall be hot dip galvanised. The zinc coating shall be uniform, adherent, smooth, reasonably bright, continuous and free from imperfections such as flux, ash, rust stains, bulky white deposits and blisters.

Insulator hardware shall be of forged steel. Malleable cast iron shall not be accepted except for insulator disc cap. The surface of hardware must be clean, smooth, without cuts, abrasion or projections. No part shall be subjected to excessive localized pressure. The metal parts shall not produce any noise generating corona under operating conditions.

c) Galvanised Steel Earth Wire

General-

The earth wire shall be standard galvanised steel earth wire having 7 strands each of 3.66 mm diameter. The galvanised steel wire shall be drawn from high carbon steel rods. The mechanical and electrical properties of the earth wire shall conform strictly to the latest edition of relevant standard.

Materials and Workmanship-

The steel wire strands shall be drawn from high carbon steel wire rods and shall conform to the following requirements as to the chemical composition:

ELEMENT	% COMPOSITION
Carbon	0.50 to 0.85
Manganese	0.50 to 1.10
Phosphorous	Not more than 0.035
Sulphur	Not more than 0.045
Silicon	0.1 to 0.35

Parameters.

Parameters:	
Material:	Galvanized steel
Purity of material:	Sulphur and phosphorous content not to exceed 0.45% each
Number of stands	7 of steel
Strands diameter	3.66 mm
Overall diameter	10.98 mm
Weight	583 kg/km approx.
Ultimate tensile strength	68.4 kN minimum.
Total cross-sectional area	73.65 sq. mm
Calculated DC resistance	2.5 ohm/km at 20 deg. C
Direction of lay outer layer.	Right hand
Protective coating for storage	Boiled linseed oil to avoid wet Stains (white rust)

d) Bus Post Insulator

The post insulators shall conform in general to latest issue of IEC 60168, IEC 60815 and IEC 60273.

Constructional Features-

Post type insulators shall consist of a porcelain part permanently secured in a metal base to be mounted on the supporting structures. They shall be capable of being mounted upright. They shall be designed to withstand any shocks to which they may be subjected to by the operation of the associated equipment. Only solid core insulators will be acceptable.

Porcelain used shall be homogeneous, free from lamination, cavities and other flaws or imperfections that might affect the mechanical or dielectric quality and shall be thoroughly vitrified, tough and impervious to moisture. Glazing of the porcelain shall be of uniform brown in colour, free from blisters, burrs and other similar defects.

The insulator shall have alternate long and short sheds with aerodynamic profile. The shed profile shall also meet the requirements of IEC 815 for the specified pollution level.

When operating at normal rated voltage there shall be no electric discharge between conductor and insulators which would cause corrosion or injury to conductors or insulators by the formation of substance produced by chemical action.

e) Cabinets, Boxes, Kiosks, Panels etc.

Equipment Control cabinets, junction boxes, marshalling boxes, lighting panels, terminal boxes, operating mechanism boxes, etc.

- i) Shall be of painted sheet steel. However, the junction and switch boxes shall be of hot dip galvanized sheet steel of 1.6mm thickness.
- ii) Thickness of sheet steel shall be 2mm cold rolled or 2.5 mm hot rolled.
- iii) Top of the boxes shall be sloped towards rear.
- iv) The cabinets/boxes/kiosks/panels shall be free standing or wall mounting or pedestal mounting type. They shall have hinged doors with padlocking arrangement. All doors, removable covers and plates shall be gasketed all around with neoprene gaskets.
- v) The cable entry shall be from bottom for which removable gasketed cable gland plates shall be provided. Suitable 230V, single phase 50Hz AC heaters with thermostats controlled by switch and fuse shall be provided to maintain inside temperature 10 deg. above the ambient.
- vi) Each cabinets/boxes/kiosk/panels shall also be provided with two earthing pads to receive 75 mm x 12mm GS flat. The connection shall be bolted type with two bolts per pad. The hinged door shall be connected to body using flexible wire.
- vii) The cabinets/boxes/kiosk/panels shall also be provided with danger plate, and internal wiring diagram pasted on inside of the door. The front label shall be on a 3 mm thick plastic plate with white letter engraved on black background.
- viii) All the boxes, panels shall be suitable for outdoor installation having degree of protection not less than IP: 55 as per IEC60529.
- ix) Panels/distribution board/kiosks etc. to be located outdoor shall have rain hood/canopy.

x) Bay Marshalling Kiosk (BMK)

1. Each bay of the switchyard shall be provided with a Bay marshalling Kiosk (BMK) located at a convenient location to receive and distribute cables within the bay.
2. It shall receive two incoming, three phase AC supplies, two 110V DC incoming supplies controlled by MCBs with auto changeover provision and distribute adequate three/single phase ac supplies controlled by MCBs. Of the outgoing feeder, 20% shall be kept spare.
3. Adequate terminal blocks (having 20% spare terminal) shall be provided in separate compartment in BMK for implementing interlocking schemes for operation of switchyard equipment interlocking schemes for operation of switchyard equipment (circuit breaker, disconnecting and earth switches etc)
4. 100A, 5-pin receptacles of industrial type suitable for outdoor fitting shall be provided in the BMK for connecting to welding sets/other emergency equipment.

Adequate terminal blocks shall be provided for control wires required for interlocking.

16.9 Switchyard Structures

16.9.1 Scope

The scope of galvanised structural steel works includes all works related to design, engineering, supply, preparation of design and fabrication drawings, procurement of all materials, fabrication, galvanising, proto-assembly, testing, transportation to Site, building, storage and successful erection of the following structures for 132kV switchyard, interconnection between switchyard and Power House (unit feeders) and Switchyard to Power House (SST feeder).

- i) All columns/towers/beams including stub templates for 132kV Switchyard.
- ii) All supporting structures (lattice type) for 132kV Switchyard equipment/items such as Circuit Breakers, Isolators.
- iii) All supporting structures (pipe type) for 132kV Switchyard equipment/items such as Instrument Transformers, Lightning Arresters, Post Insulators, etc.
- iv) Structures for Cable supports.
- v) All number plates, phase plates, danger plates, etc.
- vi) All other miscellaneous steel works required for successful completion of the works under this Contract.

The scope of the Contractor shall include, design, engineering, preparation of fabrication drawings, procurement of materials, fabrication, galvanizing, proto-assembly, testing, supply and transportation to Site, handling, storage and erection of galvanised steel structures.

The scope of supply also includes all types of bolts, nuts inserts in concrete, gusset plates, equipment mounting bolts, structure earthing bolts, foundation bolts, splicing bolts, spring washers and any other item as required to complete the job.

The Tenderer shall fabricate, supply, paint and erect structural steel including cable tray supports and their embedment (in outdoor sub-station) in cable trenches as per cable trench drawings.

16.9.2 General Requirements

The Contractor must have established steel fabrication facilities in his works or at the works of his associates. The galvanising bath plant and equipment available for fabrication, testing facilities available in their works and other institution which they intend to make use of shall be stated in the offer and shall not be changed without the approval of the Engineer.

No sublet orders shall be placed by the Contractor with manufacturers or subcontractors without prior approval of the Engineer and when such approval is given, copies of all drawings/specifications referred to in the sublet orders shall be furnished to the Corporation.

16.9.3 Specific requirement of structures

a) Details of Structures

The layout of the Switchyard and the structural details are indicated in the drawings, enclosed in drawing volume.

The layouts are tentative and may undergo changes if required. The desired height of columns and bus supporting structure and the length of beams, etc. are marked in the drawings. The tenderer may restrict the type of columns and beams to minimum according to the loads to which they are subjected to. The tenderer shall furnish the details such as guaranteed weight, minimum and maximum factor of safety, permissible stresses in members, etc.

Designs and Drawings

The Contractor shall prepare the designs of all the switchyard structures and submit the design drawings along with all analysis and design calculations for the approval of Engineer. Before taking up the design, the Contractor shall prepare and submit to Engineer for approval detailed design criteria for the design of Switchyard structures.

The Contractor may proceed with the preparation of fabrication drawings based on submitted design drawings. These fabrication drawings shall, however, be modified or revised based on the approved design drawings at no extra cost of Employer.

The Contractor shall submit to Engineer design drawings containing the following information along with analysis design calculations for the approval.

- i) The schematic diagram of the columns, beams, supporting structures, etc. indicating there in the design section of all members, design forces at the joints and span.
- ii) Typical details of all main joints of the structures including typical details of gusset plates, welding, erection bolts location, etc.
- iii) Typical details of bracing including the sizes of sections.
- iv) Typical cross section of the structural details of stubs for columns.

- v) Details of beam's connection with the columns, typical details of joints with various members.
- vi) Fully dimensioned drawing for each type of structure showing sizes of all steel sections, fittings, bolts, attachments, etc. and clearance diagrams.
- vii) Dimensioned drawings for stubs.
- viii) Dimensioned drawings for stub setting templates.

The fabrication drawings to be prepared and furnished by the Contractor shall be based on approved design drawings. These drawings shall indicate complete details of fabrication and erection including all erection splicing details and typical fabrication splicing details, joint details showing the size and number of bolts, lacing details weld sizes and lengths (if any), bill of materials in a proforma approved by the Engineer, bolts and nut schedules and all other customary details in accordance with standard structural engineering practice whether or not specified.

The fabrication drawings prepared by the Contractor shall indicate the size of sections shown in the design drawings/sections substituting with the approval of the Engineer and the weight with relevance to IEC Practice for Structural Identification (erection) marks for purpose of despatch and erection, etc.

The total weight of each member as well as an abstract of weights shall also be indicated in the fabrication drawing. The weights of nuts and bolts shall be included in the consolidated schedule/bill of materials showing the length, size, weight and numbers required for each fabricated member.

The fabrication work shall start only after the final approval of the fabrication drawings is accorded by the Engineer. Such approval shall, however, not relieve the Contractor of his responsibility for the safety of the structure and good connections and any loss or damage occurring due to defective design and workmanship shall be borne entirely by the Contractor.

The design of structures shall be prepared on the basis of normal sizes of steel sections available in India.

Design Criteria-

- i) All structures shall be designed for the worst combination of dead loads, live loads, wind loads, Importance factor of 1.5, loads due to deviation of conductor, load due to unbalanced tension in conductor, torsional load due to unbalanced vertical and horizontal forces, erection loads, short circuit forces including "snatch" in the case of bundled conductors etc. Short circuit forces shall be calculated considering a fault level as specified elsewhere, IEC-60865 may be followed for evaluation of short circuit forces.
- ii) Switchyard gantry structures shall be designed for the two conditions i.e. normal condition and short circuit condition. In both conditions the design of all structures shall be based on the assumption that stringing is done only on one side i.e. all the three (phase) conductors broken on the other side.
- iii) Vertical load of half the span of conductors/string and the earth wires on either side of the beam shall be taken into account for the purpose of design. Weight of man with tools shall be considered as 150 kg for the design of structures.
- iv) Terminal/line take off gantries shall be designed for a minimum conductor tension as specified below. The design of these terminal gantries shall also be checked considering +/- 30 deg.

deviation of conductor in both vertical and horizontal planes. For other gantries the structural layout requirements shall be adopted in design.

- v) The girders shall be connected with lattice columns by bolted joints.
- vi) All pipe support used for supporting equipments shall be designed for the worst combination of dead loads, erection load. Wind load/seismic forces, short circuit forces and operating forces acting on the equipment and associated bus bars.
- vii) If luminaries are proposed to be fixed on gantries/towers, then the proper loading for the same shall be considered while designing.

b) Loading Details

The structure shall be of structural steel shall be designed most economically for the worst combination of dead load, live load and wind/seismic loads. Wherever applicable, short circuit forces and secondary effects such as shrinkages, rise or fall in temperature etc. shall also be considered in combination with above loads.

The following loads shall be considered while designing the switchyard steel structures:

- i) Wind load on structures conductors, ground wires, insulator strings etc.

For the purpose of calculating the wind loads on structures, conductors and ground wires and insulator strings etc. International standards such as IEC, Lao electrical Standards shall be applicable.

- ii) Transverse loads, vertical loads, longitudinal loads

Transverse loads, vertical loads, longitudinal loads shall be computed for reliability, security and safety requirements. The following tentative values of maximum tension loading of the ACSR conductor in the switchyard under worst conditions of temperature and wind pressure are given.

Line conductor 2000 kg/conductor

Ground Wire 2000 kg/conductor

Bus conductor 2000 kg/conductor

The contractor shall check the above values during the time of detailed engineering and furnish the obtained values along with the supporting calculations to the Engineer for approval. Moreover, the above values are minimum and higher value may need to be adopted as per design requirement of the switchyard.

c) Design of Members

Minimum thickness.

No steel section shall be less than 6mm in thickness if used for leg members and 5mm if used for other members.

However, the minimum size of leg member shall not be less than 65x65x6 mm and that of bracing member 45x45x5 mm.

d) Galvanising

Unless otherwise specified, all structural steel including ladders, platforms, hand rails and the like and all exterior and interior steel surfaces of outdoor plant, as well as bolts and nuts associated with galvanized parts shall be hot-dip galvanized, electrolytically galvanized as may be appropriate to the particular case.

Galvanising shall be performed in accordance with BS729/BSENISO1461 or other relevant Standard.

Purity of zinc to be used shall be 99.5% as per BS3436.

The weight of the zinc coating shall be atleast 0.615kg/m² unless coated otherwise. Stub members, anchor bolts shall have heavier zinc coating not less than 0.80kg/m².

Galvanising of each member shall be carried out in one complete immersion. Double dipping shall not be permitted. When the steel section is removed from the galvanising kettle, excess spelter shall be removed by bumping only.

All bolt, nuts, locknuts, washers etc. shall be hot dip galvanised. Excess spelter from bolts, nuts etc. shall be removed by centrifugal spinning. Threading after galvanising shall not be permitted.

Defects in certain members indicating of impurities in the galvanizing bath in quantities larger than permitted as per specification or lack of quality control in any manner in the galvanising plant shall render the entire production in the relevant shift liable to rejection.

e) Stresses

The maximum permissible stresses of axial, bending, shear, bearing, combined stresses for structural members and bolts in kg/cm² shall conform to latest edition of relevant international standard. For supporting structures fabricated out of steel, stresses shall conform to latest edition of relevant international standard.

Erection Stresses:

Where erection stresses combined with other permissibly co-existent stress could produce a working stress in any member applicably greater than the specified working stresses, such additional material shall be added to the member or such other provision be made as necessary to bring the working stresses within the specified limit.

f) Insulator Attachment and Ground wire Clamps

Necessary attachments to the beams, columns and cones for fixing the insulator attachment and the earth wire rod clamps as required to suit the beams and columns are to be provided as below:

- i) Strain plates of adequate strength shall be provided at required points for attachment of tension insulator hardware.
- ii) Hangers or U bolts for attachment of suspension insulators, hardware, etc. shall be provided at suitable points.
- iii) Earth wire rods to be provided at suitable points on the peak of columns.
- iv) Provision for earthing shall be made in the main members of structures.

g) Earthing of the Structures

The main members of steel structures shall be earthed by galvanised iron flats, which are connected separately at each column to the earthing system. The earthing flats are not covered by the specification but the Contractor shall provide the bolts and clamps required for connecting the flats.

h) Bolts, Nuts and Washers

All bolts and nuts shall conform to the latest edition of ISO-398 or the approved standard. All bolts should have hexagonal heads, the heads being forged out of solid and be truly concentric with the shank which must be perfectly straight.

All bolts should be threaded to take the full depth of the nut and shall be threaded for enough to permit firm gripping of the member. All nuts shall be held tight to the bolts, steel and wrought iron tapered washers shall be provided wherever necessary.

Ten percent excess bolts, nuts and washers shall be provided. The Contractor must give the size of bolts, size of holes and other special details of this character but no bolts less than 16mm diameter shall be used.

Galvanised spring washers shall be provided for insertion under all nuts.

i) Welding and related Works

For welding, edge preparation, electrodes, Preheating Inter-run Temperature and Post Weld Heat Treatment, Sequence of Welding, Testing of Welders, Inspection of Welds, Rectification of Defective Welding Work, Acceptance of Welded Structures, Danger Board, Stub Angles and Templates, Marking, Galvanising, Painting, Test of Works, Rejection of Material, etc. refer to General Technical Specification.

j) Steel Work in Concrete

All steel works embedded in concrete shall not be galvanised or coated with any paint. One shop coat of linseed oil would be sufficient and the same should be removed at site, before embedding the steel in concrete.

k) Shop Assembly and Testing

Before delivery, one complete structure of each type shall be assembled in the shop to ensure correct fit of the pieces. If any pieces are found to be incorrectly fabricated, all of such pieces shall be checked and corrected to ensure proper fit in the field.

Prototype testing of representative structures shall be done in accordance with the approved procedure in presence of Employer's representative and test certificates submitted for approval to the Employer.

16.10 Switchyard Erection

16.10.1 General

These specifications cover the erection, testing & commissioning of 132 kV outdoor switchyard for the project.

Erection works shall conform in all respects with the requirements of the latest issue of relevant International Standard, Nepal Electricity Act and Nepal Electricity Rules and equivalent IEC/BS/IEEE/ASTM standards except where specified otherwise.

16.10.2 Specific Requirements

i) Equipment Erection Details

For equipment interconnection, the surfaces of equipment terminal pads, Aluminium tube, conductor & terminal clamps and connectors shall be properly cleaned. After cleaning, contact grease shall be applied on the contact surfaces of equipment terminal pad, Aluminium tube/conductor and terminal clamps to avoid any air gap in between. Subsequently bolts of the terminal pad/terminal connectors shall be tightened and the surfaces shall be cleaned properly after equipment interconnection.

Muslin or leather cloth shall be used for cleaning the inside and outside of hollow insulators.

All support insulators, circuit breaker interrupters and other fragile equipment shall preferably be handled with cranes having suitable booms and handling capacity.

Bending of Aluminium tube and compressed air piping if any should be done by a bending machine and through cold bending only. Bending shall be such that inner diameter of pipe is not reduced. Cutting of the pipes wherever required shall be such as to avoid flaring of the ends. Hence only a proper pipe cutting tool shall be used.

Hacksaw shall not be used. Handling of equipment shall be done strictly as per manufacturer /supplier's instructions/instruction manual. Handling equipment, sling ropes etc. should be tested periodically before erection for strength. The slings shall be of sufficient length to avoid any damage to insulator due to excessive swing, scratching by sling ropes etc.

The Conductor tensions shall be as indicated in the specification of switchyard structure above. However, the contractor shall have to carry out Sag-Tension calculation to ensure proper electrical clearances of the conductor. In case the same is not maintained with the specified tension, due measures shall be undertaken in the switchyard structure to achieve the same in respective bays.

All tension insulator strings shall have double tension string arrangement.

Corona rings & corona bells shall be used wherever required and same shall be of non-magnetic material. The requirements regarding RIV and corona extinction voltage shall include terminal fittings.

The connectors for termination of conductor on equipment shall be either of rigid or expansion type suitable for single panther ACSR conductor as per the layout drawing with suitable sub-conductor spacing.

The switchyard shall be provided with suitable phase markers and danger plates.

Generator Connections:

If necessary generator overhead stringing shall be brought to a bus post insulator and then connected to the transformer bushing so as to avoid mechanical forces on the LA.

The connections from LA to transformer shall be through shortest electrical distance.

ii) Directly Buried Cables

The Contractor shall construct the cable trenches required for directly buried cables wherever required.

The scope of work shall include excavation, preparation of sand bedding, soil cover, supply and installation of brick or concrete protective covers, back filling and ramming, supply and installation of route markers and joint markers. The Bidder shall ascertain the soil conditions prevailing at site, before submitting the bid.

The cable (power and control) between LT station, control room, DG set location and fire lighting pump house shall be laid in the buried cable trenches. In addition to the above, for lighting purpose also, buried cable trench can be used in outdoor area.

Cable route and joint markers and RCC warning covers shall be provided wherever required. The voltage grade of cables shall be engraved on the marker.

iii) Installation of Cables

For specific requirement of installation of cables, the Particular Technical Specification of Cables & accessories shall be referred. However, the following requirement shall be adopted for switchyard cablings:

Cabling in the control room shall be done on ladder type cable trays while cabling in switchyard area shall be done on angles in the trench. All cables from bay cable trench to equipments including and all interpole cables (both power and control) for all equipment, shall be laid in GI pipes of minimum 50 mm nominal outside diameter of medium class, which shall be buried in the ground at a depth of 250mm below finish formation level. The size of the conduit/pipe shall be selected on the basis of 40% fill criterion. Separate GI pipes shall be laid for control and power cables. Cable pull boxes of adequate size shall be provided if required.

Suitable arrangement should be used between fixed pipe / cable trays and equipment terminal boxes, where vibration is anticipated.

Power and control cables in the cable trench shall be laid in separate tiers. The order of laying of various cables shall be as follows, for cables other than directly buried.

- a) Power cables on top tiers.
- b) Control instrumentation and other service cables in bottom tiers.

Single core cables in trefoil formation shall be laid with a distance of three times the diameter of cable between trefoil centre lines. All power cables shall be laid with a minimum centre to centre distance equal to twice the diameter of the cable of higher size of cables.

Trefoil clamps for single core cables shall be of pressure die cast aluminum (LM- 6), Nylon -6 or fibre glass and shall include necessary fixing GI nuts, bolts, washer etc. These are required at every 2 meter of cable runs.

Power and control cables shall be securely fixed to the trays/supports with self locking type nylon ties with deinterlocking facility at every 5 metre interval for horizontal run. Vertical and inclined cable runs shall be secured with 25 mm wide and 2 mm thick aluminium strip clamps at every 2m.

Cables shall not be bent below the minimum permissible limit. The permissible limits are as follows or as specified by the manufacturer:

Where cables cross roads, drains and rail tracks, these shall be laid in reinforced spun concrete or steel pipes buried at not less than one meter depth. In each cable run some extra length shall be kept at a suitable point to enable one (for LT cables)/two (for H.T. cables) straight through joints to be made in case the cable develop fault at a later date.

Selection of cable drums for each run shall be so planned as to avoid using straight through joints. Cable splices will not be permitted except where called for by the drawings, unavoidable or where permitted by the Owner. If straight through joints are unavoidable, the Contractor shall use the straight through joints kit of reputed make.

Control cable terminations inside equipment enclosures shall have sufficient lengths so that changing of termination in terminal blocks can be done without requiring any splicing.

Metal screen and armour of the cable shall be bonded to the earthing system of the station, wherever required by the Owner.

Rollers shall be used at intervals of about two metres while pulling cables. All due care shall be taken during unreeling, laying and termination of cable to avoid damage due to twist, kinks, sharp bends, etc.

Cable ends shall be kept sealed to prevent damage. In cable vault, fire resistant seal shall be provided underneath the panels.

iv) Earthing

The earthing shall be done in accordance with requirements given in Particular Technical Specification of Earthing System. However, the following technical requirements are to be considered while designing & erection of switchyard earthing system.

Neutral points of systems of different voltages, metallic enclosures and frame works associated with all current carrying equipment and extraneous metal works associated with electric system shall be connected to a single earthing system unless stipulated otherwise.

Earthing and lightning protection system installation shall be in strict accordance with the latest editions of Nepal Electricity Rules, relevant standards and Codes of practice and Regulations existing in the locality where the system is to be installed.

a) Guide for safety in AC substation Grounding. IEEE Std. 80.

Equipment and Structure Earthing

Earthing pads shall be provided for the apparatus/equipment at accessible position. The connection between earthing pads and the earthing grid shall be made by two short earthing leads (one direct and another through the support structure) free from kinks and splices. In case earthing pads are not provided on the item to be earthed, same shall be provided in consultation with Owner.

Whether specifically shown in drawings or not, steel/RCC columns, metallic stairs etc. shall be connected to the nearby earthing grid conductor by two earthing leads. Electrical continuity shall be ensured by bonding different sections of hand-rails and metallic stairs.

Wherever earthing conductor crosses or runs along metallic structures such as gas, water, steam conduits, etc. and steel reinforcement in concrete it shall be bonded to the same.

Light poles, junction boxes on the poles, cable and cable boxes/glands, lockout switches etc. shall be connected to the earthing conductor running along with the supply cable which in turn shall be connected to earthing grid conductor at a minimum two points whether specifically shown or not.

Earthing conductor shall be buried 2000 mm outside the switchyard fence. All the gates and every alternate post of the fence shall be connected to earthing grid.

The stone spreading shall also be done 2000 mm outside switchyard fence. The criterion for stone spreading shall be followed in line with requirement specified elsewhere in the specification.

All lighting panels, junction boxes, receptacles fixtures, conduits etc. shall be grounded.

A continuous ground conductor of 16 SWG GI wire shall be run all along each conduit run. The conductor shall be connected to each panel ground bus. All junction boxes, receptacles, switches, lighting fixtures etc. shall be connected to this 16 SWG ground conductor.

Power Cable Earthing-

Metallic sheaths and armour of all multi core power cables shall be earthed at both equipment and switchgear end. Sheath and armour of single core power cables shall be earthed at switchgear end only.

i) Lightning Protection

Direct stroke lightning protection (DSLPP) shall be provided in the HV switchyard by lightning spikes and shield wires. The layout drawings enclosed indicate the tentative arrangement. The final arrangement shall be decided after approval of the DSLPP calculations.

Technical requirement and for scope, the particular technical specification of Lightning protection system shall be referred. However, the following requirement may be achieved.

The lightning protection system shall not be in direct contact with underground metallic service ducts and cab.

Down conductors shall be cleated on the structures at 2000 mm interval. Connection between each down conductor and rod electrodes shall be made via test joint (pad type compression clamp) located approximately 1500 mm above ground level. The rod electrode shall be further joined with the main earthmat. Lightning conductors shall not pass through or run inside G.I. conduits.

ii) Illumination System

The illumination system for switchyard shall include outdoor lighting poles with suitable yard lighting / flood light fixtures, Peripheral roads shall be provided with lighting poles mounted with road lighting fixtures.

For the scope and technical requirement of switchyard, Particular technical specification of Illumination shall be referred.

Lighting power supply shall be derived from ACDB in switchyard control building.

16.11 Spare Parts

The spare parts mentioned here under are meant for use by the Employer during operation and maintenance stage and shall not be used as erection spares required during installation.

16.11.1 Specified Spare Parts

Following spares shall be considered for supply.

A) Circuit Breakers

- i) One pole of CB complete with support structure and. operating mechanism box etc. : 1 No
- ii) Relay, power contactors and switch fuses for electrical control circuit (consisting of one no. each of all types) : 1 Set
- iii) Set of gaskets, rings and seals : 1 Set
- iv) Tripping and closing coil: 2 Nos. each type
- v) Set of valve for pneumatically operated circuit breaker (If required) : 1Set
- vi) Pressure switch set for pneumatically operated circuit breaker (if required) : 1 Set
- vii) Terminal Connectors : 2 Nos. each type

B) Isolators

- i) One complete pole with 1 earth switch along with operating mechanism etc.: 1 No.

- i) Copper/ aluminium contact fingers for female contact : 2 Sets of each type
- ii) Relays, power contactor, switch fusesfor electrical : 1 Set
control circuit (one no of each type and rating)
- iii) Rotary bearing of isolator : 1 Set of each type
- iv) Limit switch and auxiliary switch : 2 Set
- v) Terminal connectors : 3 Nos. each type
- A) Current Transformers
 - i) Current Transformer complete in all respects : 1 No. of each type
 - ii) Terminal Connectors for above : 1 No each type
- B) EMVT
 - i) EMVT complete in all respects : 1 No. of each type
 - ii) Terminal Connectors for above : 1 No. of each type
- C) Surge Arrestors
 - i) Surge arrester complete with surgecounter : 1 No. of each type
 - ii) Surge counter monitor : 1 No. each type
 - iii) Terminal Connectors for above : 1 No. each type
- D) Post Insulators
 - i) Bus Post Insulators : 5% of total requirement
of each type
 - ii) Terminal Connectors : 2 Nos. each type
- E) Others
 - i) Disc Insulators : 5% of total requirement

- | | | |
|--|---|------------------------------------|
| ii) PG clamps for conductor | : | conductor type |
| iii) T-connectors for conductors | : | 10 Nos. for each conductor type |
| iv) Hardware clamps/connectors for string insulators | : | 10% of total qty used of each type |
| v) Rigid type/expansion type connectors | : | 10% of total qty used of each type |
| vi) ACSR conductor | : | 10% of each type used |
| vii) Ground wire | : | 10% of each type used |

NOTE: -

Set means complete replacement for one equipment (CB, Isolator, CT, LA etc. of each type)

For CB, CT, CVT/EMVT and Surge Arrestors, “Nos” means complete replacement of one pole/phase of the equipment.

16.11.2 Recommended Spare Parts

The Bidder shall furnish the list of recommended spare parts as per “General Technical Specification (GTS)”.

16.12 Tools and instruments

The contractor shall supply all necessary tools, devices, equipment, testing instruments etc. for installation, repair and maintenance as described in following sub clauses.

16.12.1 Special Tools

The contractor shall supply all the necessary special tools and devices for installation, repair and maintenance of each item of equipment/component supplied under this section as recommended by manufacturer(s). The list of these items including their make and detailed specification shall be as proposed by Owner at the time of award of the contract.

All special tools shall be clearly marked to identify their use and shall be made available for the installation works to be undertaken by the Contractor. Special tools shall be shipped with the first consignment of equipment to be installed.

The tools shall be delivered to the Owner prior to taking over, in perfect condition or be replaced, if necessary, with new tools of equal or better quality than the original ones.

16.12.2 Tools for erection and installation

The contractor shall bring his own tools, devices, testing instruments/equipment to site in order to erect and install the complete equipment delivered under this section. These shall remain the property of the contractor unless otherwise agreed to take over any/all of these at mutually agreed conditions.

For on-site assembly, the contractor shall use the same assembly tooling and procedures as those used in the shop.

16.12.3 Testing instruments

The contractor shall supply testing instruments of internationally reputed make having proven acceptance in the field for use during testing and commissioning and operation stage. The list of these instruments including their make and detailed specification shall be as proposed and accepted by the Owner at the time of award of the contract.

All other electrical testing and measuring equipment are covered in the relevant section of particular technical specification.

16.13 Drawings, Documents and Design Calculations

16.13.1 Drawings

The following minimum drawings shall be submitted by the contractor for review and approval.

- i. Single line diagram of switchyard scheme.
- ii. Layout drawing of equipments.
- iii. Electrical clearance diagram.
- iv. Erection Key Diagram.
- v. Structure layout and loading diagram.
- vi. OGA drawings of each equipment.
- vii. Schematic diagram of control system.
- viii. Foundation arrangement drawing of equipment.
- ix. Cable trench lay out and sectional drawing.
- x. Drainage layout drawing.
- xi. OGA drawing of each type of terminal connector, clamp, insulators etc.

16.13.2 Documents

The following minimum documents shall be submitted by the contractor, some of which are for review and approval.

- i. Catalogues/operational & maintenance manual of equipment.
- ii. Quality Assurance Plan.
- iii. Data Sheets.

16.13.3 Design calculations

The contractor shall submit the design calculation minimum for the following for review and approval.

- i. Earthing system.
- ii. Illumination system.
- iii. Structure design calculation as detailed in relevant clause.
- iv. Span of support insulator calculation.
- v. DSLP calculation.
- vi. Sag-Tension calculation.
- vii. Mechanical force on strung bus, insulator due to short circuit.

16.14 Quality Control and Assurance

To ensure quality during each stage of work, the Contractor shall establish a system defining quality assurance plan/procedures during various stages of work.

The contractor shall maintain quality control during manufacturing of equipment as per the approved quality assurance plan. Inspection and testing shall be carried out as per the approved quality assurance plan at various stages of manufacturing for assuring the full compliance of supply with the requirements of specification.

The Contractor shall follow approved site quality assurance plan and installation procedures. The contractor shall maintain the quality record during site installation and commissioning which shall be produced to the Owner for approval.

Inspection and tests shall be carried out at site by the Owner during installation and commissioning stages as described in the relevant clauses.

All subcontractors including vendors associated in completing the supply and work under this section shall have their own quality assurance system conforming to ISO 9000 series and certified by an internationally acceptable organisation.

16.15 Tests

16.15.1 Shop Test

1) Type test:

Type tests shall verify that all components of the protection system perform satisfactorily at the rating assigned. All equipments proposed according to this specification shall be type tested at typical units in accordance with the relevant IS/IEC standards.

The type test is not be mandatory if similar typical units of protection system have been type tested and test certificates for relevant tests are accepted by the Owner.

The Contractor shall prepare written documents, in a form agreed upon by the Contractor and the Owner, of all test certificates/ results and hand over these documents to the Owner in due course of time for review and acceptance. The contractor at his own costs shall conduct the type test (s) for which certificates is not acceptable to the Owner.

a) Circuit Breakers

In accordance with the requirements specified above the circuit breaker alongwith its operating mechanism shall conform to IEC: 62271-100.

The test reports of the type tests for regular BIL, electrical and mechanical performance and the following additional type tests shall be submitted for Owner's review.

- i) Corona extinction voltage test.
- ii) Out of phase closing test as per IEC: 62271-100.
- iii) Line charging breaking current.
- iv) Test to demonstrate the Power Frequency withstand capability of breaker in open condition at Zero Gauge pressure.
- v) Seismic withstand test in unpressurised condition.
- vi) Verification of the degree of protection.
- vii) Static Terminal Load test.

Routine Tests-

Routine tests as per IEC: 62271-100 shall be performed on all circuit breakers.

Site Tests:

All routine tests except power frequency voltage dry withstand test on main circuit breaker shall be repeated on the completely assembled breaker at site.

b) Isolators

In accordance with the requirements as specified above, type tests certificates as per IEC 129, IEC 1129 shall be furnished to Owner for approval. The following additional type test / reports shall also be furnished for approval.

- i) Mechanical Endurance test (50 operations on one isolator)
- ii) Radio Interference Voltage Test
- iii) Corona Extinction Voltage Test

Routine Tests-

All routine tests as per IEC shall be performed on the isolators.

Site Tests

All routine tests except Mechanical endurance test, power frequency withstand test will be performed on completely assembled isolator at site.

- c) Current Transformers

In accordance with IEC 60044-1, valid type test certificates shall be furnished for Owner's approval.

The following additional type test reports shall also be furnished:

- i) Radio interference test.
- ii) Thermal stability test, i.e. application of rated voltage and rated extended thermal current simultaneously by synthetic test circuit.
- iii) Thermal co-efficient test i.e. measurement of tan delta as a function of temperature (at ambient and between 80oC & 90oC) and voltage (at 0.3, 0.7, 1.0 and 1.1 Um/V3).
- iv) The current transformer shall be subjected to Fast Transient test to assess the CT performance in service to withstand the high frequency over voltage generated due to closing & opening operation of breakers. Method as per IEC: 44-1 may be followed.

Routine Tests-

All routine tests as per IEC shall be performed on the current transformers.

Site Tests-

All site tests as per IEC shall be carried out at site. Some of which are indicated below:

- v) Insulation Resistance Test.
- vi) Polarity Test.
- vii) Ratio identification test - checking of all ratios on all cores by primary injection of current.
- viii) Dielectric test of oil (wherever applicable).

- ix) Magnetising characteristics test.
- d) Voltage Transformers and Capacitive Voltage Transformers

In accordance with IEC 358/IEC 60186, valid type test certificates shall be furnished for Owner's approval.

Routine Tests-

All routine tests as per relevant IEC shall be carried out on the VTs.

Site Tests-

All site test as per IEC shall be carried out at site. Some of which are indicated below:

- Insulation resistance test.
- Polarity test.
- Ratio test.
- Dielectric test of oil (wherever applicable).

- e) Lightning Arrestor

Type Test Reports of the Surge Arrestor as per IEC-99 shall be furnished by the manufacturer. They should be valid and special tests if carried out shall be indicated.

Routine Tests-

All routine test as per relevant IEC shall be carried out on the Las. Some of them are indicated below:

- i) Measurement of reference voltage
- ii) Residual Voltage test of arrestor unit
- iii) Internal ionization or partial discharge test
- iv) Sealing Test
- v) Verticality test on assembled unit as a sample in a lot.

Site Tests-

All site test as per IEC shall be carried out at site. Some of which are indicated below: i) Leakage current measurement

- 11) Resistance of ground connection.

- f) Tests on Insulator Strings and Hardware

In accordance with the stipulations of the specification, the suspension and tension strings, insulator and hardware shall be subjected to the following type tests, acceptance tests and routine tests:

Type Tests on Insulator Strings:

The test reports for following type tests shall be submitted for approval.

- i) Power frequency voltage withstand test with corona control rings under wet condition as per IEC- 60383.
- ii) Lightning Impulse voltage withstand test with corona control rings under dry condition as per IEC-60383.
- iii) Voltage distribution test (Dry)

The voltage across each insulator unit shall be measured by sphere gap method. The result obtained shall be converted into percentage. The voltage across any disc shall not exceed 9% and 10% for the suspension string and tension insulator string.

- iv) Corona Extinction Voltage test (Dry)

The sample assembly when subjected to power frequency voltage shall have a corona extinction voltage of not less than specified kV (rms) for EHV line for line to ground under dry condition. There shall be no evidence of Corona on any part of the sample. The atmospheric condition during testing shall be recorded and the test results shall be accordingly corrected with suitable correction factor as stipulated in IEC 60383.

- v) RIV Test (Dry)

Under the conditions as specified above the insulator string alongwith complete hardware fittings shall have a radio interference voltage level below specified microvolts at 1 MHz when subjected to 50 Hz AC line to ground voltage of specified value for the string under dry conditions. The test procedure shall be in accordance with IEC 60437.

- vi) Mechanical strength test

The complete insulator string along with its hardware fitting excluding arcing horn, corona control ring, grading ring, tension/suspension clamps shall be subjected to a load equal to 50% of the specified minimum ultimate tensile strength (UTS which shall be increased at a steady rate to 67% of the minimum UTS specified. The load shall be held for five minutes and then removed. After removal of the load, the string components shall not show any visual deformation and it shall be possible to dismantle them by hand. The string shall then be reassembled and loaded to 50% of UTS and the load shall be further increased at a steady rate till the specified minimum UTS and held for one minute. No fracture should occur during this period. The applied load shall then be increased until the failing load is reached and the value recorded.

Type Tests on Insulators

Type test report for Thermal Mechanical Performance tests as per IEC -60575, Clause 3 / IEC: 61109, clause 5.1 (for composite long rod insulators) shall be submitted for approval.

Acceptance Tests for Insulators:

- i) Visual examination as per IEC-60383/ IEC-61109 clause no. 7.2 (for composite long rod insulators).

- ii) Verification of Dimensions as per IEC- 60383.
- iii) Temperature cycle test as per IEC- 60383.
- iv) Puncture Test as per IEC-60383 (Applicable only for porcelain insulators).
- v) Galvanizing Test as per IEC- 60383.
- vi) Mechanical performance test as per IEC-60575 Cl. 4 / IEC-61109 clause no. 7.2 (for composite long rod insulators).
- vii) Test on locking device for ball and socket coupling as per IEC-60372(2).
- viii) Porosity test as per IEC- 60383 (Applicable only for porcelain insulators).
- ix) Thermal shock test as per IEC-60383 (Applicable only for glass insulators)

Acceptance Test on Hardware Fitting

- i) Visual Examination as per Cl. 5.10 of IS: 2486 (Part-I).
- ii) Verification of Dimensions as per Cl. 5.8 of IS: 2486 (Part-I)
- iii) Galvanizing/Electroplating tests as per Cl. 5.9 of IS: 2486 (Part-I).
- iv) Slip strength test as per Cl. 5.4 of IS-2486 (part-I).
- v) Shore hardness test for the Elastometer (if applicable as per the value guaranteed by the Bidder).
- vi) Mechanical strength test for each component (including corona control rings and arcing horns). The load shall be so applied that the component is stressed in the same way as it would be in actual service and the procedure as given earlier should be followed.
- vii) Test on locking devices for ball and socket coupling as per IEC -60372(2).

Routine Test on Insulator-

- i) Visual Inspection as per IEC-60383.
- ii) Mechanical Routine Test as per IEC-60383.
- iii) Electrical Routine Test as per IEC-60383.

On Hardware Fittings-

- i) Visual examination as per IEC-61109 (for composite long rod insulators).
- ii) Mechanical strength Test as per IEC-61109 (for composite long rod insulators).

g) Tests on ACSR Conductors

The following type, acceptance & routine tests and tests during manufacturing shall be carried out on the conductor.

Type Tests-

In accordance with the stipulation of specification, the following type tests reports of the conductor shall be submitted for approval.

- i) UTS test on stranded conductor
- ii) Corona extinction voltage test - dry
- iii) Radio Interference voltage test - dry
- iv) DC resistance test on stranded conductor

Acceptance Tests-

- i) Visual check for joints, scratches etc. and lengths of conductor.
- ii) Dimensional check on steel and aluminium strands.
- iii) Check for lay ratios of various layers.
- iv) Galvanizing test on steel strands.
- v) Torsion and Elongation test on steel strands.
- vi) Breaking load test on steel and aluminium strands.
- vii) Wrap test on steel and aluminium strands IS: 398 (Part V) 1982.
- viii) DC resistance test on aluminium strands.
- ix) UTS test on welded joint of aluminium strands

NOTE:

All the above tests except test mentioned at (a) shall be carried out on aluminium and steel strands after stranding only.

Routine Tests-

- i) Check to ensure that the joints are as per specification.
- ii) Check that there are no cuts, fins etc. on the strands.
- iii) All acceptance tests as mentioned above to be carried out on each coil.
- h) Tests for GS Earthwire

The following type, routine & acceptance tests and tests during manufacturing shall be carried out on the earth-wire.

Type Tests-

In accordance with the stipulation of specification, the following type tests reports of the earth-wire shall be submitted for approval.

- i) UTS test.
- j)) DC resistance test

Acceptance Tests-

- i) Visual check for joints, scratches etc. and length of Earth-wire
- ii) Dimensional check
- iii) Galvanizing test
- iv) Lay length check
- v) Torsion test
- vi) Elongation test
- vii) Wrap test
- viii) DC resistance test as per IEC 61089
- ix) Breaking load test
- x) Chemical Analysis of steel

Routine Tests-

- i) Check that there are no cuts, fins etc. on the strands.
- ii) Check for correctness of stranding.

16.15.2 Field test

All field tests including tests during installation, pre-commissioning, commissioning, performance and field acceptance tests shall be conducted by the Contractor, in the presence of Owner's representative.

Procedure to be adopted for conducting the operational, pre-commissioning, commissioning, performance and field acceptance test shall be submitted well in advance, at least six (6) months before start of relevant testing for Owner approval.

The equipments/system shall be deemed to be commissioned and ready for trial run only after successful operation for a "test service period" specified in sub clause "Performance Testing". In the event of any failure, this period shall be repeated for any number of times till the successful operation as described above is achieved.

- i) Tests during installation and pre commissioning:

At least the following tests shall be performed by the Contractor:

- Ratio and Polarity tests of CTs, PTs, CVTs.
- Correctness of interconnections between CTs, CVTs and PTs as well as CT groups and associated relays.
- Checking of all electrical clearances.
- Checking of interlocks.
- Checking of alignment.
- Visual checking of charged line & equipment.
- Functional tests of circuit breakers & isolators.
- Check for earthing system.
- Co-ordination with protection & SCADA system.

ii) Commissioning tests:

At least the following tests shall be performed by the Contractor:

- High voltage test on main circuits.
- Charging of line to system nominal & highest system voltage & visual checking.
- All other tests not mentioned specifically but required by IEC shall be performed.

iii) Performance tests:

If nothing unusual has been observed after energization, the test service period of 72 hours shall follow. During the test service period, the switchyard equipment must perform correctly without any abnormality.

The contractor shall be responsible for the equipment during test service and also for the way it is operated. However, owner's personnel will operate the equipment under the Contractor's guidance during test period.

iv) Field acceptance test:

This test phase shall ensure the trouble free operation of the switchyard equipment.

- All protection requirements & signals are complete.
- SCADA requirements are complete.
- Operation of each equipment to the satisfaction of Owner.
- All statutory electrical clearances are achieved.

- All statutory clearances from inspecting authority are obtained.

16.15.3 Test report

Shortly after completion of the field acceptance tests the Contractor shall prepare and forward draft copies of the field acceptance test report to the Owner for review. After review and acceptance, the contractor shall furnish six (6) copies of the final report.

16.16 Delivery, Installation and Commissioning

16.16.1 Packaging, Handling and site Storage

The contractor shall follow the “General Technical Specifications” for packaging, handling and storage requirement.

The contractor shall pack all the consignment in sea worthy packaging strong enough to withstand rough handling during transit. Equipment surface shall be suitably protected against scratches, corrosion, shocks, impact etc. Packages shall be suitably and distinctively identified for type of handling and kind of storage.

Electronic equipment shall be packaged, shipped and stored in anti-static packing. All packages shall be stored indoor. Packages containing electronic equipment shall be stored in humidity controlled environment.

16.16.2 Site installation and Commissioning

General:

The contractor shall follow the requirements of installation elaborated in “General Technical Specification”.

The contractor has to do all the work related to assembly, erection, testing and commissioning complete in all respects. All necessary tools, plants, labour, materials including consumables for performing installation, testing and pre-commissioning shall be provided by the contractor.

The contractor shall submit the necessary data/information, layout and foundation/support drawings well in advance.

The contractor shall provide and install the concrete inserts/embedment; support steels and/or components for foundation/supports purpose as per approved erection drawings and coordinate the activities with civil contractors to keep his activities in synchronism with civil works. All installation for foundation shall be verified and accepted by the Owner.

The contractor shall use anchor fasteners for installation of fixtures, mounting, conduits, cabling, panels etc. Chipping of concrete and/or taking support from reinforcement bars shall not be allowed.

The contractor shall supply sufficient number of erection and commissioning spares based on their experience so that erection, testing and commissioning work progresses smoothly and is not hampered for want of such spares. These spares shall be in addition to the spare parts described under clause: “Spare Parts”.