PART - 2

TECHNICAL REQUIREMENTS

CONTENTS

1. Scope

1.1 This technical specification specifies the minimum requirement for design, manufacture, inspection and testing of Ring Main Unit (RMU) to be installed at 33 kV junction points to have continuous supply by isolating faulty sections. The RMU shall be of extensible type for future expansion and shall consist of either circuit breaker feeders or LBS feeders or combination of both. The number of ways (feeders) of RMU and feeder configuration shall be mentioned in BOQ. The RMU shall be of single bus bar SF6 gas insulated outdoor or indoor metal enclosed type and shall be suitable for installation in severe outdoor environmental conditions.

1.2 **SCADA compatibility of RMUs:** The RMUs shall be suitable for remote operation i.e. All the functions within the RMU (circuit Breakers / LBS) shall be fitted and supplied with motorized operation. The RMU should be provided with provision of necessary terminal blocks which shall be used for connecting the RTUs/FRTUs for automations. The RMU should have compatibility with IEC – 104 SCADA system and suitable to indicate ON/OFF position of CB, Earth Switch, Gas pressure, RMU door open, common power supply healthy, spring charges status, FPI indication and etc. All analog data from RMU (viz. from relay, meters etc.) should be available in an open protocol format for integration to SCADA through RTUs or FRTUs.

2. Applicable Codes and Standards

Unless otherwise specified elsewhere in this specification, the RMU, Switchgears, Instrument Transformers and other associated accessories shall conform to the latest revisions and amendments thereof of the following standards.

Device	Description	Standard
Switchgear	General requirement for Metal Enclosed Switchgear and Control gears, Bus bars	IEC62 271- 1
		IEC 62 271-200
Enclosure	HV/LV prefabricated substation	IEC 62271-201/IEC 61330
Devices	Circuit Breakers	IEC 62 271-100
	Load Break Isolators and Earthing switches	IEC 62 271-102
	Voltage detecting systems	IEC 61 243-5
	Fault passage indicators	IEC 61869-2
Degree of Protection	Degree of protection provided by enclosures	IEC 60 529
SF6 Gas	Specification and acceptance of new Sulphur hexafluoride	IEC 60376
Insulation Coordination	Definition, principles & Rules	IEC 60 071- 1
Instrument Transformers	Current Transformers	IEC 60 044-1
	Voltage Transformers	IEC 60 044-2

3. Service Condition

- The general operating temperature shall be from -10°C to +40°C.
- Manufacturer shall declare whether the RMU is able to operate in air temperature higher than +40 °C and confirm that current de-rating is not necessary.
- The RMU shall be capable of being exposed to high relative humidity and ambient air pollution.

4. System Parameters

Description	Parameters	
		33 kV
Network		Three phases – Three wires
Rated Voltage		36 kV
Service Voltage		33 kV
System Frequency		50 Hz
Lightning Impulse withstand Voltage		170 kV (p)*
Power Frequency withstand voltage		70 kVrms*
Rated Normal Current		630 A
Rated Short time withstand current kA rms(3 sec)		20 kA (Minimum)
Rated breaking current (kA rms)		20 kA
Rated making current (kAp)		50 kAp

** For installations at an altitude higher than 1000 m, the insulation withstand level of external insulation (i.e. phase-phase, phase-earth clearances of cables, BIL of CTs & PTs) at the service location shall be determined by multiplying the rated insulation levels by a factor Ka in accordance with figure 1 of IEC 62271-1 standard.*

5. RMU Enclosure for Outdoor Installation

The enclosure with ring main unit fitted must be a compact metallic suitable for outdoor installation and to be operated on three phase three wire / 33 kV, 50 Hz system with short time current rating of 20 kA for 3 sec. The enclosure shall be protection degree of IP 54 rating for outdoor application. The enclosure with RMU fitted shall be internal arc classified to from front, lateral and rear and type tested according to IEC 62271-202/IEC 61330. The enclosure shall consist of two wide opening access doors with holdbacks, allowing easy operator access to switchgear and shall be provided with door locking mechanism for security. Two earth points internal or external to the enclosure to be specified. The roof of the enclosure shall be tilted to 20° to avoid accumulation of water.

6. Color of the Enclosure

The color of an enclosure can be RAL 7032.

7. Switch Board Requirement (Main Tank)

The RMU shall meet the criteria for compact, metal-enclosed indoor switchgear in accordance with IEC 62271-200. The main tank of the RMU shall include, within the same stainless steel / metallized epoxy enclosure, the number of MV functional units required for connection and power supply, the circuit breaker feeders, LBS feeders and earthing switches. The SF6 gas tank shall be made of TIG welded stainless steel to have the best welded quality. The gas cubicle shall be metal enclosed with stainless steel of minimum 2 mm thickness and should be provided with a pressure relief arrangement away from the operator. The gas tank shall be of completely welded construction.

The switchgear and bus bar enclosure shall be filled with SF6 at 0.2 bar to 0.8 bar relative pressure to ensure the insulation and breaking functions. Sealed for life, the enclosure shall meet the "sealed pressure system" criterion in accordance with the IEC 62271 – 200 standard, a system for which no handling of gas is required throughout 30 years of service life. So, refilling valve is not required. In addition, manufacturer shall confirm that maximum leakage rate is lower than 0.1 % / year. The SF6 gas pressure inside the tank shall be constantly monitored by providing appropriate indicator (green and red pressure zones) on the front side of the panel. The tank shall be of stainless steel sheet of minimum 2.5 mm thickness and shall have IP67 protection index. The tank shall be able to withstand an accidental internal overpressure of at least 2.2 bars and suitable pressure withstand test report should be submitted with the bid. Also the bursting pressure of the tank should not be less than 5.5 bars. Any accidental over pressure inside the sealed chamber shall be limited by the opening of a pressure-limiting device in the rear or bottom part of the enclosure. Gas will be released to the rear of the switchgear away from the operator. All the manual operations should be carried out on the font of the switchgear.

Each switchboard shall be identified by an appropriately sized label which clearly indicates the functional units and their electrical characteristics. The tank shall be of internal arc classification of IAC A and type tested for internal arc tests as per IEC on front, lateral and rear side.

8. Dielectric Medium

SF6 gas shall be the dielectric medium for RMUs. SF6 gas used for the filling of the RMU shall be in accordance with IEC 376. There shall be an absorption material fitted inside the tank to absorb the moisture from the SF6 gas and to regenerate the SF6 gas following arc interruption.

9. Bus bars

Bus bars shall consisted of three numbers of EC grade tinned copper of current rating 630 Amps. The Short time rating current shall be 20 kA for 3 seconds for 33 kV system. The Bus bar connections shall be of anti-oxide greased.

10. Load Break Switches (LBS)

The LBS provided must be fully insulated by SF6 gas. The operating mechanism shall be spring assisted mechanism with operating handle for ON /OFF. All the mechanical interlocking must also work when the LBS are operated by motor drive. The earth switch shall be naturally interlocked to prevent the main and earth switch being switched 'ON' at the same time. The selection of the main and earth switch is made by a lever on the facia, which is allowed to move only if the main or earth switch is in the off position. Each LBS shall be of the triple pole (open-disconnected, closed and earthed). The rated current of LBS shall be 630 Amps continuous at maximum ambient temperatures. Motor is to be provided for spring charging mechanism along with suitable battery and its charger. The LBS shall be provided with a motorized operating mechanism that can be remotely monitored and controlled from the SCADA.

11. Earthing Switches

There shall be continuity between the metallic parts of the switch board and cables so that there is no electric field pattern in the surrounding air, thereby ensuring the safety of people. The substation frames shall be connected to the main earth busbar without dismantling any busbar.
Earthing of the main circuit: The cables shall be earthed by an earthing switch with short-circuit making capacity, in compliance with IEC 62271-2 standard. The earthing switch can only be operated when the switch is open.
The earthing switch shall be fitted with its own operating mechanism and manual closing shall be driven by a fast-acting mechanism, independent of operator action. The moving contacts of the earthing switch shall be visible in the closed position through transparent covers. Mechanical interlocking systems shall prevent access to the operating shaft to avoid all operator errors such as closing the earthing switch when the LBS or CB is closed.

12. Circuit-breaker

The circuit breakers shall have 3 positions: open-disconnected, closed and earthed and shall be constructed in such a way that natural interlocks prevent all unauthorized operations. Closing and opening operation of the Circuit Breaker shall be done from remote by using shunt trip coil. Spring charging shall be done with motorized spring operating mechanism. The circuit breaker shall be fitted with a mechanical indicator on the panel front facia for indicating VCB ON/OFF positions.

It shall be fitted with a local system for manual tripping by an integrated push button. There shall be no automatic reclosing. The position of the power and earthing contacts shall be clearly visible on the front of the switchboard. The position indicator shall provide positive contact indication in accordance with relevant standards. The circuit shall be associated with an integrated protection unit that will operate without any auxiliary power supply and shall include:

a) Three toroid transformers;
b) Self-powered microprocessor relay supplied should be compatible to communicate to FRTU/SCADA equipment on MODBUS protocol;
c) A low energy release;
d) A "fast-on" test receptacle for protection testing (with or without CB tripping);
e) The protection system will ensure circuit breaker tripping as of a minimum operating current (Is) which is the rated current of the underground network to be protected and maybe set to following ratings from 10 A to 600 A.
Following settings shall be available:

Range 1 - 10 to 50 A
Range 2 - 40 to 200 A
Range 3 - 63 to 312 A
Range 4 - 250 to 600 A

f) The phase and earth fault protection shall have two separately adjustable settings;
g) Interlocking of RMU panels i.e. for breaker panel and cable compartments must be designed according to IEC 62271-200;
h) The rated operating sequence shall be O-3min-CO-3 min-CO;
i) The Circuit Breaker shall be provided with a motorized operating mechanism that can be remotely monitored and controlled from the SCADA;
j) The arc quenching medium for interrupter shall be either of SF6 or Vacuum;
k) The MAKEs of the interrupter of the CB shall be restricted to following brands:
    - ABB
    - SIEMENS
    - Schneider
    - L & T

The interrupter Makes is restricted to the brand as mentioned above and bidders are to quote accordingly. The Item/lots for which brands are restricted, no alternative/ substitute brand shall be accepted and shall be considered as non-responsive for that particular item/lot.

13. Cable Compartment

The ring main units must be equipped with the outer cone connection bushings in compliance with DIN 47 636, part 6 with M-16 inside thread. The cover of cable compartment should not be of bolted type. The access to the cable compartment shall be available preferably from the front side apart from any other access as per the manufacturer's design.

The connection points of each outgoing feeder must be horizontally situated in one level at a height of approximately 700mm starting from the bottom of the unit. The cable boxes shall be suitable for connection of 3 CORE HV XLPE cables of assorted sizes up to 400 Sq. mm.

Connecting possibilities for angle plugs and T plugs shall be provided. Cable brackets inside the cable connecting compartments must be vertically and horizontally adjustable. The cable compartment shall be arc resistant as per IEC 62271-200 amended up to-date. The internal arc fault test on cable compartment shall be carried out as per IEC. The degree of protection for cable covers shall be IP 3X. The cable bushings inside the cable compartment shall have the minimum clearances as follows:

Parameters	**unit**		**33 kV**
Air insulation of cable bushings* • Phase to Phase • Phase to Earth	mm		 350 222
Basic Insulation Level of cable bushings * • Lightning impulse voltage • Power frequency voltage	kVp kV rms		 170 70

**Above values are the standard values at 1000 meters ASL. For installing at an altitude higher than 1000 m, the insulation withstand level of external insulation and the clearances shall be corrected in accordance with relevant standard for the altitude of the site.*

14. Cable Bushings

The units shall be fitted with the standardized bushings that comply with IEC standard. All the bushings shall be at the same height from the gland plate and shall be protected by a cable boot. Necessary suitable cable boots shall be supplied as a part of RMU.

15. Voltage indicator lamps and phase comparators

Each function shall be equipped with a fixed type voltage indicator box on the front of the device to indicate whether or not there is voltage in the cables. The capacitive dividers will supply low voltage power to the lamps. Three inlets can be used to check the synchronization of phases. This device shall be in compliance with IEC 61243-5 standard.

16. Fault Passage Indicators (FPIs)

FPI shall be provided per Isolators (LBS). The device should be in compliance with IEC 61869-2 standard. These shall facilitate quick detection of faulty section of line. The fault indication may be on the basis of monitoring fault current flow through the device. The unit should be self-contained requiring no auxiliary power supply. The FPI shall be integral part of RMU and shall have LCD/LED display, automatic reset facility. They shall be fully field-programmable for earth fault and phase to phase fault. It shall also have potential free contracts for SCADA.

17. Front plate

The front plate shall have an IP2X degree of protection. The front shall include a clear mimic diagram which indicates the different functions. The position indicators shall give a true reflection of the position of the main contacts. They shall be clearly visible to the operator. The lever operating direction shall be clearly indicated in the mimic diagram. The manufacturer's plate shall include the switchboard's main electrical characteristics.

18. RMUs Motors

a) RMUs must be fitted with motors to operate LBS and circuit-breaker functions. The motors shall be provided in the RMU and shall be, 24 V, DC Motor (with smooth mechanical operation/ prefer electrical operation);
b) Installation on site shall be possible with the RMU fully energized and manufacturer should provide detailed instructions for installation to the control mechanism. Auxiliary contacts for remote indication of switch status are also required;
c) The fitting of the motors to the mechanism must not in any way impede or interfere with the manual operation of the switches. An auxiliary contact to prevent motorized operation of the mechanism while the operating handle is inserted into the operating point must also be provided;
d) A 24V battery (2 nos. 12V battery) shall be provided with at least 1 hour backup;
e) The RMU shall be provided with potential-free contacts and control contacts for DI/DOs to be interfaced with FRTU so that the RMU is capable of being monitored and controlled by SCADA/DMS.

19. Battery Charger

The battery charger shall have input voltage of 230V AC, 50Hz and output voltage of 24V DC. Battery shall be sealed maintenance free, lead acid 12V batteries of two numbers.

20. HT Current Transformer and Potential Transformer (Metering & Protection)

The RMU shall be provided with 2 core HT epoxy cast resin type CTs for metering and protection. The CT ratio, accuracy class and burden shall be as follows:

Voltage	Parameters	Functions	
		Metering	Protection
33 kV	Ratio	As per SLD	As per SLD
	Accuracy	0.5s	5P10
	Burden	15	2.5 VA

21. Space Heater

Space heater should be provided in the HV cable termination compartment with thermal sensors. The space heater shall be 230 V, 15 Watt with thermostat.

22. Tests

Following type test shall be submitted and the type test report should have been carried out within 5 years from the date of opening of the tender.

- Power frequency and Impulse withstand test of the complete RMU Unit;
- Temperature-rise test of the completed RMU Unit,
- Short-time withstand current and duration test of the complete RMU Unit,
- Mechanical operation test on breakers,
- Degree of protection test for each compartment,
- Making and breaking test of an apparatus i.e. Circuit Breaker, Load Breaker Switch & Earthing
- Switches.
- Internal arc withstand test for main tank and cable compartment inside the enclosure
- Partial discharge test for complete RMU unit
- Pressure withstand test

Acceptance and routine tests shall include the following:

- Withstand voltage at power frequency for all current carrying parts including wiring.
- Measurement of resistance of the Main circuit.
- Gas leakage Test.
- Partial Discharge test.
- Withstand voltage on Auxiliary Circuit.
- Operation of Function Locks, interlocks, Signaling Devices and Auxiliary Devices.
- Suitability & correct operation of Protection, Control Instruments and electrical connections of the circuit breaker operating mechanism (Primary & Secondary Injection).

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Section 2A – Technical Requirement (General)

TABLE OF CLAUSES

PART 2A - GENERAL TECHNICAL REQUIREMENTS

1.1 Project Description

Bhutan Power Corporation Limited (BPC) intends to Construct Distribution Network as a part of Power Supply arrangement for Montanga Industrial Park, Samdrupjongkhar.

The scope includes following:

i. Supply and Installation 33kV RMU/USS.
ii. Supply and laying of UG Cables.
iii. Testing and commissioning.

1.1.1 This document and specification calls for the manufacture, testing at manufacturer's works, supply and delivery, storage, erection, testing and commissioning of the works required for the Project.

1.2 Format of Specification

This specification describes equipment required in the project summarized in Section 2 B and 2 C:

Brief Description	Major works
Equipment	Supply, Installation Testing and commissioning of 33kV RMU and/or Package Secondary Substation of multiple ways.
Cabling System	33kV cables from incomer pole structure to RMUs and CSS to form Ring of 33kV Network.

Any appended drawings of the required equipment /works form part of this specification.

1.3 Scope of Work

The Contract includes the manufacture, testing at manufacturer's works, delivery, storage at site, insurance, erection, testing and commissioning of the Equipment as specified including all civil works. The Contractor shall be responsible for proper completion of the work till it is formally taken over by the Employer.

The quantities given are estimated quantities. It should be clearly understood that the contract will be on "item rate turnkey basis".

Detailed scope of the works is as per the BOQ and specifications of the bidding documents.

1.4 Language

The English language shall be used in all Contract documentation and in all correspondence between the Contractor and the Employer.

1.5 Units of Measurement

Metric units of measurement (System International) shall be used in all Contract documentation. Angular measurement shall in degrees with 90 degrees comprise one right angle.

1.6 International Standards

All Equipment and the Works under this Specification shall conform to the latest editions of the International Electrotechnical Commission (IEC) or Bureau of Indian Standards (BIS) Specifications.

1.7 Site Conditions

1.7.1 Elevation

The elevation above sea level is 173 m at Samdrupjongkhar.

1.7.2 Special Conditions

Particular problems, which shall receive special consideration, relate to operation of the equipment in wide ranging temperatures and the presence of moisture, insects and vermin.

1.7.3 Access

Samtse is accessible from Phuentsholing/Samdrupjongkhar, Bhutan by road. The site is nearly 696 km (via within Bhutan) from the Paro international airport and it is 104 km by road from Guwahati Airport (India). Bidders are informed to visit and work in the project locations, special permits from the Ministry of Home Affairs are required which is required to be processed from Thimphu and Regional Immigration Offices located at Phuentsholing, Gelephu and Samdrupjongkhar. For processing the permits, BPC will provide only assistance and permits need to be processed by contractor themselves. Such cost shall be borne by the contractor and included in the project cost.

1.8 Electrical Characteristics

1.8.1 Design Features for 33 kV, 11 kV and 415 V Equipment

Nominal system Voltage	33kV	11 kV	11 kV	415 V
Location	Indoor	Outdoor	Indoor	Indoor
Highest system Voltage kV	36	12	12	415/ 240 [1]
System neutral earthing	Solidly earthed	Solidly earthed	Solidly earthed	Solidly earthed
Minimum Clearances in air				
a) Between phases - mm	351	280	130	-
b) Phase to earth - mm	222	140	80	-
c) Section clearance -mm	2800	2600	2600	-
d) Ground clearance -mm	3700	3700	3700	-

Ph-Ph spacing for Bus-mm	-	1200	-	-
Insulation levels a) 1 minute power frequency kVrms b) 1.2/50 microsecond impulse kVp	 70 170	 28 75	 28 75	 2 6
Creepage distance mm	N/A	240	N/A	
No. of phases	3	3	3	3
Frequency Hz	50	50	50	50
Equipment suitable for short circuit withstand MVA	1500 (for 3 sec)	350 (for 3 sec.)	350 (for 3 sec.)	55kA (for 3 sec.)

[1] *415/240 V no load. 400/230 V on load*

The above are the values for 1000 m altitude and shall be corrected based on the elevation for various places for which the equipment shall be designed.

1.8.2 Creepage Distance

The creepage distance shall not be less than 25 mm/kV.

1.9 **Spare Parts, Tools and Appliances**

The bidder shall attach the spares, special tools and/ or appliances which are recommended.

The Employer may order all, none or any of the recommended items. Those ordered shall be delivered not later than the date of receipt of the last shipment of the associated item of plant. The price of the items shall be subject to the same price conditions as the associated item of plant.

All spares shall be interchangeable with the original parts. They shall be treated and packed for long term storage under the climatic conditions of site.

Each item shall be clearly and permanently labeled on the outside of its container with its description and purpose. When several items are packed in one case, a general description of the contents shall be given on the outside of the case. Spare parts shall not be shipped in the same cases as components, which are used for erection. The cases shall be clearly labeled to indicate that they contain spare parts or tools and each tool or appliance shall be clearly marked with its size and purpose.

All case containers or other packages are liable to be opened for inspection and checking on site.

The cost of recommended spares, special tools (other than those specified in the BOQ) will not be taken into consideration when comparing bids.

1.10 Electrical Power Supplies

a) Power Supplies

Power supplies for plant and equipment shall be:

i. 400 V, 3 phase, 4-wire, 50 Hz for power.
ii. 230 V, 1 phase, 50 Hz for lighting, indication, and anti-condensation heaters.
iii. 110 V DC for relays, essential indication, CB spring charging, controls/ protection, alarms, CB tripping and closing.

b) Miniature Circuit Breakers

Means shall be provided for protection and isolation of circuits associated with protection, control and instruments. They shall be of approved type and grouped, as far as possible, according to their functions. They shall be clearly labeled both on the panels and the associated wiring diagrams.

Miniature circuit breakers shall be of the thermal and magnetic tripping type, and comply with IEC 60898 and IEC 60947-2.

c) Instruments

All electrical instruments and meters shall comply with IEC 60051 and IEC 61010 and, unless otherwise specified, shall be of industrial grade accuracy. Three-phase power measuring instruments shall be of the three-phase unbalanced load pattern wherever the current and Voltage references permit. Energy meters shall be three phase four wire having maximum demand indicator, RS485 port and optical port.

All indicating and recording instruments shall be digital type, flush mounted in dust proof cases complying with IEC 60068 and dimensions to IEC 61554.

The size of all indicating instruments shall be 96 mm square with long scale and instruments supplied from transducers shall have 4-20 mA movements.

Instrument dials for analogue meter if any shall be white with black markings. A red line shall be drawn on each scale to represent rated conditions. Bezels shall have uniform semi-gloss black high-grade finish.

The movements of all electrically actuated instruments shall be of the deadbeat type. Instruments shall be provided with a readily accessible zero adjustment wherever possible.

d) Terminals

Moulding materials shall be self-extinguishing or resistant to flame propagation, substantially non-hygroscopic and shall not carbonise when tested for tracking. The insulation between any terminal & framework or between adjacent terminals shall withstand a test of 2 kV

rms. for one minute. The mouldings shall be mechanically robust to withstand handling while making terminations.

All terminals shall be mounted in accessible positions. Adjacent terminals shall be adequately spaced with respect to each other and to the incoming cable gland plate. Separate terminations shall be provided on each terminal strip for the cores of incoming and outgoing cables including all spare cores.

Terminal blocks for CT and VT secondary leads shall be provided with test links and isolating facilities. Terminals provided for current transformers shall incorporate facilities to enable secondary windings to be short-circuited without disturbing fixed wiring and earthing facilities.

Terminations for circuits operating at Voltages greater than 60 V shall be protected by transparent insulating covers marked with the working Voltages.

DC circuit terminals shall be segregated from AC terminals.

Unless otherwise specified, all the terminal blocks except the terminal blocks for CTs shall be suitable for connecting minimum two 2.5 sq.mm copper conductors of the external cables at each connecting point. The terminal blocks for CTs and PTs shall be suitable for connecting minimum of 4.0 sq. mm and 2.5 sq. mm copper conductors respectively.

All spare contacts and terminals of the panel mounted equipment and devices shall be wired to terminal blocks.

The terminal assemblies shall give the required number of ways plus 20% spare with a minimum of 5 terminals. These shall be uniformly distributed on all rows of terminal blocks.

e) <u>Panel Wiring</u>

All wiring shall be carried out with 1100 V grade, single core, stranded copper conductor wires with FRLS PVC insulation and shall be Vermin, rodent proof. The minimum size of the stranded copper conductor used for panel wiring shall be as follows:

a) All circuits except CT circuits : 2.5 mm^2 per lead.
b) CT Circuit : 4 mm^2 per lead.

The minimum number of strands per conductor shall be seven. Extra flexible wires shall be used for wiring of devices mounted on moving parts such as swinging panels and doors.

The wiring shall be bound and supported by clamping, roughing or lacing. Spiral wrapping will not be accepted. Wireways shall not be more than 50% full. Adequate slack wire shall be provided to allow for one re-stripping and reconnection at the end of each wire. When screened cables or wires are necessary, an insulating sheath shall be included. Wiring and supports shall be of fire resistant material. Wiring shall only be jointed or teed at terminals. Terminals of the clamp type shall not have more than two wires connected.

f) Wire Colour Code

Wire colours shall be as follows:

Colour	Purpose
Red	R-phase connections in current and Voltage transformer circuit only
Yellow	Y-phase connections in current and Voltage transformer circuits only
Blue	B-phase connections in current and Voltage transformer circuits only.
Green with Yellow Stripes	Connections to earth
Black	AC neutral connections, earthed or unearthed, connected to the secondary circuits of current and Voltage transformers.
Any other Colours	AC connections other than those above.

Alternatively, where equipment is wired in accordance with a manufacturer's standard diagram, wiring may be carried out in a single colour except that all connections to earth shall be green with yellow stripes.

g) Terminations and Ferrules

The ends of every wire and every cable tail shall be fitted with numbered ferrules of white with alpha numbers clearly engraved in black. **The ferruling should be as per BEBS-S12 (1964).**

Moisture and oil resisting insulating material shall be used. The ferrules shall be of the interlocking type and shall grip the insulation firmly.

Wires and terminals associated with tripping circuits shall be distinctively marked.

h) Electrical Insulation

Insulating materials shall be finished to prevent deterioration of their qualities under the specified working conditions.

Plastics, elastomers, resin-bonded laminates and inorganic materials shall be of suitable quality selected from the grades or types in the appropriate IEC Standard.

All cut or machined surfaces and edges of resin-bonded laminates shall be cleaned and then sealed with an approved Varnish as soon as possible after cutting.

i) Electronic and Control Equipment

Equipment shall be capable of withstanding randomly phased transient over-voltages of either polarity on the power supply or interruptions of the power supply without damage or impairment to the equipment's subsequent performance. In the case of controls, no mal-operation shall occur.

Where manufacturers require that electronic equipment supplied under this Contract should not be subjected to insulation resistance tests ("Meggering"), suitable warning notices shall be provided and installed in appropriate locations.

No thermionic valves shall be used in the equipment. Wherever possible, integrated circuits shall be used.

It shall be possible to remove/replace card from/to electronic equipment without damage and without interfering with the operation of the rest of the equipment or system. If necessary, consideration should be given to switching off the supplies locally to a card to prevent inadvertent interference to the equipment or system during removing/replacing a card.

j) Alternating Current Supply Practice

Double-pole switches shall be used to break single-phase ac mains supplies. For multi-phase supplies, each phase shall be switched simultaneously and the neutral should preferably not be switched. If it is switched, it shall be opened after and closed before the phase-lines.

All mains circuits shall be protected only in the phase-lines by MCBs of suitable rating or by other suitably approved protective devices. The neutral shall be connected by a removable link located near the protective devices.

All main transformers shall have an electrostatic screen, which shall be earthed.

k) Direct Current Supply Practice

Double pole switches shall be used to break dc supplies, one pole for the positive line and one pole for the negative.

DC circuits shall be protected by MCBs of suitable rating installed in both positive and negative lines.

Measures shall be taken to prevent arcing across switches or relay contacts which are required to break inductive circuits (e.g. bypass diodes or capacitors connected across coils).

Power supply bus bars in cubicles shall be shrouded.

The duplicate auxiliary power supply feeders shall be provided in Control panels. Auto-changeover facility in DC DB shall be provided so that in case of failure of one power source, other shall cut in

automatically. The protective relays shall not give a trip signal for momentary loss of control Voltage or during changeover of control Voltage.

l) Batteries

Electronic equipment shall not use local internal batteries unless the approval of the Engineer has been obtained. Where approval is given, batteries used inside equipment shall be of the totally sealed, leak-proof type, lithium and rechargeable type.

m) Earthing

Provision shall be made for earthing all equipment intended for connection in an ac mains supply.

All structural metal work and metal chassis shall be connected to earth. Earthing conductors shall be at least equal in cross-sectional area to the supply conductors and shall be capable of carrying the fault current for 1 second.

n) Anti-Condensation Heaters

Any items of electrical equipment which are liable to suffer from internal condensation (due to atmospheric or load variations) shall be fitted with heating devices suitable for electrical operation at 230 Volts ac, 1 phase, 50 Hz of sufficient capacity to raise the internal ambient temperature by 5°C. The electrical apparatus so protected shall be designed so that the maximum permitted rise in temperature is not exceeded if the heaters are energised while the apparatus is in operation. Where fitted, a suitable terminal box and control switch shall be provided and mounted in an accessible position. A thermostat shall be provided in the heater control circuit to cut-off the heater at 45° C.

o) Interior lighting and Receptacles

Each panel shall be provided with a compact fluorescent lamp (CFL) lighting fixture (11 W) rated for 240 V, 1 phase, 50 Hz supply for the interior illumination of the panel during maintenance. Switching of the fitting shall be controlled by the respective panel door switch. All CFL lamps shall be with pin type holder.

Each panel shall be provided with a 230 V, 1 phase, 50 Hz, 6 Amps, 3 Pin receptacle with switch. The receptacle with switch shall be mounted inside the panel at a convenient location.

1.11 **Materials and Finishes**

1.11.1 General

Unless otherwise provided for in the Contract, all materials, fixtures, fittings, and supplies furnished (hereafter called "materials") shall be new and of standard first grade quality. All assembly and construction work shall be done in a neat and professional manner. Materials shall be free of defects. Materials

shall be brought to site only after inspection and issuance of proper dispatch clearance. The dispatch clearance shall be issued within three working days after the inspection from the BPC head office. The local materials like bricks, sand aggregates shall be tested in the local laboratories before bulk supply. The cube test for the concrete shall be to the contractor account and tested in the local laboratory for the major concrete works.

All of the plant, whether temporary or permanent, shall be in accordance with the Contract with respect to character, type, construction, constituent substances, weight, strength, shape, dimensions, etc.

In choosing materials and their finishes, due regard shall be given to the harsh climatic conditions which can occur in the area. Some relaxation of the following provisions may be permitted where equipment is hermetically sealed, but weatherproof materials should be used wherever possible.

All structural members, nuts and bolts shall be galvanised and shall conform to the requirements indicated in clause 1.12 of this section.

1.11.2 Surface Coating and Galvanising

All ferrous metalwork shall be provided with an effective galvanized or corrosion resistant paint treatment applied in accordance with the best trade practice.

The paint shall be obtained from a reputed manufacturer. The formulation and application procedure shall be as recommended by the manufacturer for the appropriate exposure conditions.

All the equipment shall be painted with shade RAL 7032 (exterior) and glossy white (interior). Poles shall be painted with silver paint.

Coatings shall not be applied before Vessels and chambers have passed pressure or Vacuum tests. Precautions shall be taken to prevent corrosion occurring in the period of time between cleaning of the steel and commencing the painting.

Suitable amounts of each type and colour of finish coat as applied to the major equipment items shall be provided for "touch-up" purposes.

The colour of all topcoats shall be approved by the Engineer.

1.12 Substation structure-Nuts and Bolts

All substation structural members shall be secured by means of nuts and bolts with approved flat steel washers. Nuts and heads of all bolts shall be of the hexagonal type and of uniform outline dimension.

Minimum size of bolts for all structural connections shall be 12-mm diameter in mild steel. All bolts shall conform to IS 12427- 1988, property class 5.6.

All bolts washers and screwed rods shall be galvanized including the threaded portions. All nuts shall be galvanized with the exception of the threads, which shall be oiled. All bolts attaching insulator set droppers, U bolts and earth conductor clamps to the towers shall be provided with extra thread length to

accommodate two nuts and a washer in an approved manner. The screwed thread of any bolts or studs shall not form part of a shearing plane between members.

All washers shall be included under this Contract, including locking devices and anti-vibration arrangements, which are to be subject to the approval of the Engineer. The washers shall be of adequate thickness to abridge the projection of the shaft and the commencement of the threaded portion. Taper washers shall be fitted where necessary.

Nuts shall be finger tight on the bolt and will be rejected if they are, in the opinion of the Engineer, considered to have an excessively loose or tight fit. Bolts re-threaded after galvanizing will be rejected.

The Contractor shall allow for the supply of surplus bolts, nuts and washers in excess of the exact amount measured to allow for shortages due to loss, misappropriation etc.

Bolts of a single diameter only shall be used for a given tower/structure type, and as far possible for all tower/structure types. Only in exceptional cases different diameter bolts shall be used with the prior approval of the Engineer. But even in the latter case, for each tower/structure type, all the bolts used shall be of the same diameter.

Usage of High Tensile bolts will generally be prohibited and only in exceptional cases, it shall be allowed with prior approval of the Engineer and under the directions of the Engineer.

1.13 Castings

All castings shall be free from blowholes, flaws and cracks as far as is practicable. No welding, filling or plugging of defective parts shall be done under any circumstances. All cast-iron shall be of close-grained quality approved by the Engineer.

1.14 Welding

All joints shall be bolted joints and welded joints shall not be permitted either during the design stage or the construction stage. However, during erection in case of additional unforeseen requirements by the Employer, if welding needs to be resorted to, the same shall be done with prior approval of the Engineer, and shall conform to BIS specifications. In such a case, the Contractor shall specifically indicate the location and purpose along with the proposed methodology for welding for the Engineers' approval. The wielding shall be carried out by a certified welder who have undergone minimum of certificate level training in this trade.

1.15 Works Inspections and Testing

a) Works Tests

These are detailed in the technical specifications. The results of all works tests shall be recorded and submitted to the Engineer no later than the date of delivery of ex-works.

b) Proposed Scope of Inspection

The Engineer may at the Employer's discretion witness the works tests described in the following Technical Specification and may also make Visits to monitor progress. The Contractor shall give minimum of two weeks notice to the Employer/Engineer with a copy to Engineer, in case they desire to witness the tests, indicating date and place of Inspection.

The test equipment, meters, instruments etc. used for testing shall be calibrated at recognised test laboratories at regular intervals and Valid certificates shall be made available to the Employer's representatives at the time of testing. The calibrating instruments used as standards shall be traceable to Indian/International standards.

c) Engineer's/Employer's Authority

Inspection and witnessing of tests shall be carried out in accordance with the Conditions of Contract. The Engineer will be responsible for advising the Contractor of acceptance or rejection. The Inspector has the authority to delay delivery of any items of equipment, which have not been tested and proved in accordance with the Contract.

1.16 Packing and Shipping

Any items liable to be damaged in transit shall be effectively protected and securely fixed in their cases. All cases of over 2 tonnes shall be marked to show where slings should be placed.

All cases shall be clearly identified giving particulars of manufacturer's name and type of equipment. All identification marks on the outside of cases shall be waterproof and permanent. All electrical equipment shall be adequately sealed and desiccating agents used where necessary to prevent damage from condensation. All equipment shall be packed and protected, bearing in mind that it will be shipped to a harsh environment, that a considerable period may elapse between its arrival on site and it’s unpacking and that covered storage may not always be possible.

All wood and other materials used in packing cases shall be insect free. Adequate protection and precautions are to be taken to exclude termites and other vermin, noxious insects, larvae or fungus from the packing materials or plant. All contents are to be clearly marked for easy identification against the packing list.

The Contractor shall protect all steelwork before shipment, to prevent corrosion and/ or damage. Bundles of steel sections shall be properly tied together by an approved method and care shall be taken to ensure that they are robust and that they can be handled easily during shipment.

Bolts and nuts shall be double bagged and crated for shipment. Crating of dissimilar metals is not acceptable.

Packing cases where used, shall be strongly constructed and in no case shall timber less than 25 mm in thickness be used. The contents of packing cases shall be securely bolted or fastened in position with struts or cross battens.

Cross battens supporting weight in any direction shall not rely for their support on nails or screws driven lengthwise into the grain of the wood, but shall be supported by cleats secured from inside.

1.17 Cable Drums

HT cables shall be delivered in the steel cable drums while LT and control cable shall be delivered wound on strong wooden drums treated to an approved International Standard by Vacuum impregnation with copper-chrome-arsenate (CCA) preservative to resist rotting, termite and fungus attacks. Contractor may take back the steel cable drums. However, incase contractor has to handover the HT cables to BPC, the same shall be handed over properly rolled in the steel drums. Drums with an outside diameter exceeding 2.5 metres and an outside width exceeding 1.4 metres shall not be used except with the Engineer's approval. The central hole of the drums shall be reinforced with a steel plate of thickness not less than 10 mm to fit an axle size 95-mm diameter. The interior of the conductor drums shall be lined with bituminous paper to prevent the conductor from being in contact with timber. Waterproof paper and felt lining shall overleap at seams by at least 20 mm and the seams shall be sealed.

Drums shall be adequately protected by securely fastening substantial wooden battens around the periphery. These battens shall be secured by means of steel tap bindings.

The thread of bolts used to strengthen the cable drums shall be peened in such a way that the nut can be tightened but cannot be readily removed.

1.18 Labels

All equipment shall be provided with labels or name plates, giving a description of the equipment, together with information regarding the rating, nominal Voltage, nominal current and the like under which the item of plant in question has been designed to operate. The labels shall be permanently attached in a conspicuous position. Where this is not practicable, such labeling shall be provided on packaging to the Engineer's approval.

Labels shall be made of non-rusting metal or 3-ply lamicoid. Labels shall have white letters on black or dark blue background. The lettering size shall be 6 mm for panel designation and minimum 3 mm for device labels. The label inscriptions shall be subject to the Employer’s approval.

1.19 Locks

Provision shall be made for the locking of mechanism boxes, indoor and outdoor equipment to limit access or for the safety of personnel. The locks shall be rust proof and shall be provided as a part of the equipment.

1.20 Quality Assurance

The Bidder shall submit in the tender an outline of the quality assurance practices that will be applied to all aspects of the manufacturing process.

Within one month of receipt of a letter of acceptance (LOA) under this for equipment specification and civil works, the Contractor shall submit a detailed

Quality Assurance Manual, which conforms generally to the requirements of ISO 9002. Approval to proceed with manufacture of equipment within this Contract will not be given until this Quality Assurance Manual has been received and approved by the Engineer. Delays to the Contract completion date due to non-compliance with this specification requirement will be the Contractor's responsibility.

Major features of the Quality Assurance Scheme practiced by the Contractor and detailed in his Quality Assurance Manual shall be:

a) The Contractor has defined all staff responsibilities and the QA systems operating within the organisation for the purpose of ensuring adequate quality of the end product.

b) The Contractor has a senior officer with the authority to resolve matters of quality to the satisfaction of the Engineer.

c) The Contractor has adequate facilities under the control of properly trained staff to perform the quality control duties.

d) All production operations and test functions are properly documented and available to any relevant member of the Contractor's workforce.

e) A detailed inspection and test plan is prepared for the whole manufacturing operation.

f) Regular and systematic programs of testing are carried out for all incoming raw materials.

g) Regular calibration checks are carried out on all measuring equipment used in the manufacturing operations.

h) Statistical analyses are carried out regularly on appropriate test results to confirm that all processes are performing within the specified tolerances.

i) Adequate procedures are planned for corrective action in the event that quality checks show that performance is not satisfactory.

j) All checking activities, test results etc. are recorded on appropriate standardised forms and these are verified, certified, recorded and filed in a systematic manner.

1.21 **Site Services**

1.21.1 Living Accommodation

The Contractor has to make his own arrangements with regard to accommodation for his expatriate/local staff during the supervision of erection. No construction for temporary accommodation will be allowed within the substation area.

All dwellings and buildings existing or erected for any purpose by the Contractor shall comply with local regulations in regard to construction, water supply, sanitation and other requirements. The Contractor is responsible for

seeking approval from concerned authority whenever required to take up infrastructure works like construction of site office, labour camps, site stores, etc. Temporary construction camps are to be provided with proper sanitation and other necessary facilities. All temporary accommodation shall be removed by the Contractor when no longer required and before the granting of the Final Certificate. After the removal of accommodation the ground shall be left in a clean and tidy condition.

1.21.2 Office Accommodation

The Contractor is to bear all expenses in connection with their office accommodation, accommodation of the staffs, temporary housing and things needed for the purpose of the Contract. The Contractor is also to provide temporary site office minimum 16 sq.m together with one table with lockable drawer, three chairs (plastic) with toilet and water facilities for BPC site supervisor engaged for construction, supervision of the Works and the cost of these shall be deemed to be included in the Contract Price.

1.21.3 Medical Facilities

The Employer will not provide these and the Contractor shall make his own arrangements where these services may be required for his staff.

1.21.4 Labour Work Permits, Accommodation and Insurance

It will be the responsibility of the Contractor to ensure that all grades of expatriate labour have the current and correct work permits and or Visas, and to comply in every way with the immigration and or emigration regulations. The contractor shall also ensure that they comply with the labour laws of the country and the requirements for leave, accommodation and insurance of all his employees and the employees of his sub-contractors. The Contractor in all dealings with labour in his employ shall have due regard to all recognised festival days of rest and religious or other customs.

1.21.5 Transport to Site

The Contractor is to bear all expenses in connection with the transport to Site of all plant, material and things needed for the purpose of the Contract including warehouse rent, handling and other charges, which may occur. The Contractor is to observe any regulations, which limit loads on roads and bridges over which material may be conveyed.

1.21.6 Plant Handling and Storage

The handling and storage of any plant at the Site will be the responsibility of the Contractor. The Contractor shall arrange for suitable lay-down areas. The Contractor is to advise on the protection of all material against corrosion, theft, and mechanical damage during storage and erection at the Site.

Only galvanised structural steelwork may be stored in the open. Plant sensitive to climatic conditions must be stored in closed buildings protected from dust and humidity.

1.21.7 Access

The Contractor will be responsible for the construction and maintenance of any temporary roads. When haulage or construction roads are no longer required the Contractor shall break up hardened surfaces, remove all imported material, and shall reinstate the original surface and topsoil of the disturbed areas to a natural condition.

1.21.8 Site Sanitation

The Contractor shall ensure that every construction site is maintained in a clean and sanitary condition. The Contractor shall provide refuse collection and disposal services including sweeping of paved streets and cleaning of drainage channels. Adequate mobile or other toilets shall be provided at the work sites controlled by the Contractor. The Contractor shall ensure that such toilets remain in a hygienic condition.

1.21.9 Construction Power Supply

Contractor shall make his own arrangements for construction power supply and pay the requisite charges/fees to the BPC.

1.21.10 Lighting and Power

All power and lighting circuits shall be constructed with due regard for personnel safety and shall comply with recognised codes of practice and local regulations. All circuits shall be fitted with earth leakage systems.

1.21.11 Spoil Areas

Disposal areas for equipment foundation spoil shall be determined by mutual agreement with the Engineer, the Employer, land owners, and local authorities. It shall be the responsibility of the Contractor to ensure that spoil does not negatively impact the natural beauty, the function or ecosystems of the area. It will be the responsibility of the contractor to properly dispose off excavated soil at the designated place by the municipal corporations.

1.22 **Contractor's Responsibility**

1.22.1 Safety of Personnel

The Contractor shall afford maximum safety to personnel directly engaged on this Contract or to persons who, in the normal course of their occupation, find it necessary to utilise temporary works erected and to frequent the working area. Additional safety regulations to be followed by the Contractor at site are attached with the specifications.

Once any section of the plant has been made alive; the Contractor, the Engineer and the Employer shall establish and agree to a system for ensuring the safety of personnel and equipment. While the plant is under the control of the Contractor, the Contractor shall be primarily responsible for the safety precautions.

It will be mandatory under this contract to provide at least safety helmets and gumboots to all the personnel working at the site.

1.22.2 Contractor's Employees

The Contractor shall provide adequate transportation, accommodation, boarding and medical facilities for all personnel in his employ. He is also to comply with the requirements of all relevant Labour Laws of Bhutan.

The Contractor shall be responsible for the behavior on site of all personnel employed by him.

1.22.3 Training of Local Staff

The Contract shall include for the training of the Employer's employees in the areas corresponding to installation and commissioning of 33 & 11 kV breakers, Package substations, testing and commissioning of UG cables and general O&M of the substation at the site for period of 4 days at the respective site.

1.22.4 Progress Reports

At monthly intervals, the Contractor shall submit to the Engineer detailed progress reports (in triplicate) in an approved form indicating the stage reached in the design, ordering of material, manufacture, delivery and supervision of erection of all components of plant. All variances from the agreed schedule are to be promptly reported. These reports shall be forwarded promptly so that, on receipt by the Engineer, the information contained therein is not more than seven days out of date. One copy shall also be forwarded to the Engineer's representative on Site. These reports shall be prepared using project management software like Microsoft Project. The soft copies of the report shall also be supplied to the Engineer/ Employer.

The Contractor shall submit to the Engineer a weekly return detailing for each portion of the works separately, the numbers of the various classes of workmen employed by him on the Site, the Contractor's equipment on site, or any other information that may reasonably be required.

Access to the Contractor's and Sub-contractor's works shall be granted to the Engineer and Employer at all reasonable times for the purpose of ascertaining progress.

1.22.5 Progress Review Meetings (PRM)

The Contractor shall attend regular formal site progress review meetings with the Engineer where progress and construction-related issues will be reviewed. The Contractor shall prepare for issue the day before the meeting, detailed schedules showing separately the erection, fixing, concreting, commissioning, or other work activities planned for the next two weeks as well as progress achieved over the preceding week.

The Contractor shall also be required to attend other meetings from time to time as required for the project and the person representing the contractor shall be fully empowered to take decisions at such meetings.

1.22.6 Relations with Local Residents and Authorities

The Contractor shall liaise with local authorities on matters concerning the impact of his operations on the local communities. Any problems that cannot be resolved by the Contractor shall be referred to the Employer through the Engineer.

1.22.7 Public Relations

The Contractor shall not publish or provide any information relating to progress or financial status of the works to any person or organisation without the prior consent of the Employer.

1.22.8 Environmental Considerations

The Contractor shall ensure that construction does not negatively impact the natural beauty, the function, the amenities, or the ecosystems of the area and care shall be taken to prevent permanent damage.

All rivers and streams shall be protected from direct or indirect spills of pollutants resulting from the Contractor's activities.

The Contractor shall provide drainage facilities at each substation site, and shall revetate the surface where necessary to prevent erosion and consequent weakening of the foundations.

The Contractor shall as far as possible, protect the flora within the work sites. If areas are disturbed beyond the designated work boundaries, the Contractor shall reinstate the ground and re-establish suitable Vegetation as directed by the Engineer at no extra cost to the Employer. Such re-establishment shall take place as soon as practicable after the Engineer's request.

The Contractor and his employees shall protect all faunas living within the site area and shall ensure that hunting, shooting, bird nesting, egg collecting, or trapping does not occur. Permits to cut any trees shall be obtained from the relevant authorities through the Employer.

The Contractor shall as far as possible, restrict the dust pollution due to digging activities. Special care shall be taken to reduce the pollution by spraying water at regular intervals as per the directives of engineer or supervisor so that the effects of dusts and inconvenience to the public are minimized.

The contractor shall not dig and leave the place open for a maximum period of 7 days. The cable laying and foundation etc shall be so planned that as soon as digging is done the work is carried out and covered up. As a safety measure, the Contractor shall also barricade the working area with the warning tapes and bamboos.

Contractor shall mobilize the workforce, equipment and start the work only after getting environmental clearance from National Environment Commission. BPC shall process for theses clearances and hand over to the contractor at as early as possible after signing of the contract agreement.

The work site shall be kept neat and clean at all the times. Proper house keeping of the site and store shall be done as directed by the engineer in charge as per the directives at the site without any extra cost to the employer.

1.23 Documentation

1.23.1 General

In addition to the documentation requirements set out in the Conditions of Particular Application, the Contractor shall provide the information requested below.
Unless otherwise specified, 3 (three) copies of every item of submission shall be submitted by the Contractor.

1.23.2 The following essential drawings and information shall be submitted for approval after signing of the contract agreement before the work is put in hand.

1. Drawings for 33 kV RMU & USS - 30 days.
2. Drawings for Cables – 20 days.

1.23.3 Following drawings shall be enclosed with the bid:

a) The program in the form of a network based on the principles of PERT/CPM, detailed to cover entire scope of the project showing all activities, their duration, start and finish dates and their inter-relationships and major milestones.

1.23.4 As-Built Drawings on Completion of the Works

Prior to the issue of the Taking-Over Certificate, the Contractor shall submit four copies (one reproducible and four copies) of complete sets of As-Built drawings to the Engineer/ Employer for each item of plant as per section 2 E. Soft copies of all as-built drawings in Auto Cad shall also be submitted. This shall also be the condition for the issuance of the taking over certificate.

1.23.5 Test and Inspection Documents

The Contractor shall submit to the Engineer for approval a summary table of tests and inspections to be carried out in the manufacturer's works and at site at least 2 months before the first scheduled activity.
The schedule shall include:

- Raw materials test and inspections;
- Workshop tests and inspections;
- Site tests and an inspection, including pre-commissioning and commissioning tests.

The Contractor shall submit detailed procedures for the site tests for approval at least one month in advance of the corresponding activities, including:

- Descriptions of the inspection and test methods;
- Test or inspection sheets with dimensions and blank spaces for entering of measured values;
- Proposed dates and locations of tests and inspections.

The Contractor shall submit all final test and inspection reports to the Engineer for approval, in the case of manufacturer's works activities, before shipment of the corresponding plant items.

1.23.6 Dispatch Documents

The Contractor shall supply consignment notes bearing the reference number of each dispatch, and a list of the contents of each crate, identification numbers, dimensions, net and gross weights and where necessary, any special instructions regarding storage and the type of packaging/ handling.

1.24 **Applicability of the requirement**

The general specification and requirement shall be applicable to all the equipment and work under the contract. The equipment manufactured shall be in compliance with the general specification and detailed technical specification.

1.25 **Type Tests**

All equipment/materials shall confirm to type tests including routine acceptance and additional tests in accordance with the relevant Standards and Codes. The Bidder shall submit copies of type test for each equipment during detail engineering. The type tests report submitted shall be of the tests conducted within the last five (5) years prior to the date of Bid opening. In case the type tests reports are of the tests conducted earlier than five (5) years prior to the date of Bid opening, the Contractor shall repeat these test(s) at his cost.

1. Scope

1.1 This technical specification specifies the minimum requirement for design, manufacture, inspection and testing of Ring Main Unit (RMU) to be installed at 33 kV junction points to have continuous supply by isolating faulty sections. The RMU shall be of extensible type for future expansion and shall consist of either circuit breaker feeders or LBS feeders or combination of both. The number of ways (feeders) of RMU and feeder configuration shall be mentioned in BOQ. The RMU shall be of single bus bar SF6 gas insulated outdoor or indoor metal enclosed type and shall be suitable for installation in severe outdoor environmental conditions.

1.2 **SCADA compatibility of RMUs:** The RMUs shall be suitable for remote operation i.e. All the functions within the RMU (circuit Breakers / LBS) shall be fitted and supplied with motorized operation. The RMU should be provided with provision of necessary terminal blocks which shall be used for connecting the RTUs/FRTUs for automations. The RMU should have compatibility with IEC – 104 SCADA system and suitable to indicate ON/OFF position of CB, Earth Switch, Gas pressure, RMU door open, common power supply healthy, spring charges status, FPI indication and etc. All analog data from RMU (viz. from relay, meters etc.) should be available in an open protocol format for integration to SCADA through RTUs or FRTUs.

2. Applicable Codes and Standards

Unless otherwise specified elsewhere in this specification, the RMU, Switchgears, Instrument Transformers and other associated accessories shall conform to the latest revisions and amendments thereof of the following standards.

Device	Description	Standard
Switchgear	General requirement for Metal Enclosed Switchgear and Control gears, Bus bars	IEC62 271- 1
		IEC 62 271-200
Enclosure	HV/LV prefabricated substation	IEC 62271-201/IEC 61330
Devices	Circuit Breakers	IEC 62 271-100
	Load Break Isolators and Earthing switches	IEC 62 271-102
	Voltage detecting systems	IEC 61 243-5
	Fault passage indicators	IEC 61869-2
Degree of Protection	Degree of protection provided by enclosures	IEC 60 529
SF6 Gas	Specification and acceptance of new Sulphur hexafluoride	IEC 60376
Insulation Coordination	Definition, principles & Rules	IEC 60 071- 1
Instrument Transformers	Current Transformers	IEC 60 044-1
	Voltage Transformers	IEC 60 044-2

3. Service Condition

- The general operating temperature shall be from -10°C to +40°C.
- Manufacturer shall declare whether the RMU is able to operate in air temperature higher than +40 °C and confirm that current de-rating is not necessary.
- The RMU shall be capable of being exposed to high relative humidity and ambient air pollution.

4. System Parameters

Description	Parameters	
		33 kV
Network		Three phases – Three wires
Rated Voltage		36 kV
Service Voltage		33 kV
System Frequency		50 Hz
Lightning Impulse withstand Voltage		170 kV (p)*
Power Frequency withstand voltage		70 kVrms*
Rated Normal Current		630 A
Rated Short time withstand current kA rms(3 sec)		20 kA (Minimum)
Rated breaking current (kA rms)		20 kA
Rated making current (kAp)		50 kAp

** For installations at an altitude higher than 1000 m, the insulation withstand level of external insulation (i.e. phase-phase, phase-earth clearances of cables, BIL of CTs & PTs) at the service location shall be determined by multiplying the rated insulation levels by a factor Ka in accordance with figure 1 of IEC 62271-1 standard.*

5. RMU Enclosure for Outdoor Installation

The enclosure with ring main unit fitted must be a compact metallic suitable for outdoor installation and to be operated on three phase three wire / 33 kV, 50 Hz system with short time current rating of 20 kA for 3 sec. The enclosure shall be protection degree of IP 54 rating for outdoor application. The enclosure with RMU fitted shall be internal arc classified to from front, lateral and rear and type tested according to IEC 62271-202/IEC 61330. The enclosure shall consist of two wide opening access doors with holdbacks, allowing easy operator access to switchgear and shall be provided with door locking mechanism for security. Two earth points internal or external to the enclosure to be specified. The roof of the enclosure shall be tilted to 20° to avoid accumulation of water.

6. Color of the Enclosure

The color of an enclosure can be RAL 7032.

7. Switch Board Requirement (Main Tank)

The RMU shall meet the criteria for compact, metal-enclosed indoor switchgear in accordance with IEC 62271-200. The main tank of the RMU shall include, within the same stainless steel / metallized epoxy enclosure, the number of MV functional units required for connection and power supply, the circuit breaker feeders, LBS feeders and earthing switches. The SF6 gas tank shall be made of TIG welded stainless steel to have the best welded quality. The gas cubicle shall be metal enclosed with stainless steel of minimum 2 mm thickness and should be provided with a pressure relief arrangement away from the operator. The gas tank shall be of completely welded construction.

The switchgear and bus bar enclosure shall be filled with SF6 at 0.2 bar to 0.8 bar relative pressure to ensure the insulation and breaking functions. Sealed for life, the enclosure shall meet the "sealed pressure system" criterion in accordance with the IEC 62271 – 200 standard, a system for which no handling of gas is required throughout 30 years of service life. So, refilling valve is not required. In addition, manufacturer shall confirm that maximum leakage rate is lower than 0.1 % / year. The SF6 gas pressure inside the tank shall be constantly monitored by providing appropriate indicator (green and red pressure zones) on the front side of the panel. The tank shall be of stainless steel sheet of minimum 2.5 mm thickness and shall have IP67 protection index. The tank shall be able to withstand an accidental internal overpressure of at least 2.2 bars and suitable pressure withstand test report should be submitted with the bid. Also the bursting pressure of the tank should not be less than 5.5 bars. Any accidental over pressure inside the sealed chamber shall be limited by the opening of a pressure-limiting device in the rear or bottom part of the enclosure. Gas will be released to the rear of the switchgear away from the operator. All the manual operations should be carried out on the font of the switchgear.

Each switchboard shall be identified by an appropriately sized label which clearly indicates the functional units and their electrical characteristics. The tank shall be of internal arc classification of IAC A and type tested for internal arc tests as per IEC on front, lateral and rear side.

8. Dielectric Medium

SF6 gas shall be the dielectric medium for RMUs. SF6 gas used for the filling of the RMU shall be in accordance with IEC 376. There shall be an absorption material fitted inside the tank to absorb the moisture from the SF6 gas and to regenerate the SF6 gas following arc interruption.

9. Bus bars

Bus bars shall consisted of three numbers of EC grade tinned copper of current rating 630 Amps. The Short time rating current shall be 20 kA for 3 seconds for 33 kV system. The Bus bar connections shall be of anti-oxide greased.

10. Load Break Switches (LBS)

The LBS provided must be fully insulated by SF6 gas. The operating mechanism shall be spring assisted mechanism with operating handle for ON /OFF. All the mechanical interlocking must also work when the LBS are operated by motor drive. The earth switch shall be naturally interlocked to prevent the main and earth switch being switched 'ON' at the same time. The selection of the main and earth switch is made by a lever on the facia, which is allowed to move only if the main or earth switch is in the off position. Each LBS shall be of the triple pole (open-disconnected, closed and earthed). The rated current of LBS shall be 630 Amps continuous at maximum ambient temperatures. Motor is to be provided for spring charging mechanism along with suitable battery and its charger. The LBS shall be provided with a motorized operating mechanism that can be remotely monitored and controlled from the SCADA.

11. Earthing Switches

There shall be continuity between the metallic parts of the switch board and cables so that there is no electric field pattern in the surrounding air, thereby ensuring the safety of people. The substation frames shall be connected to the main earth busbar without dismantling any busbar.
Earthing of the main circuit: The cables shall be earthed by an earthing switch with short-circuit making capacity, in compliance with IEC 62271-2 standard. The earthing switch can only be operated when the switch is open.
The earthing switch shall be fitted with its own operating mechanism and manual closing shall be driven by a fast-acting mechanism, independent of operator action. The moving contacts of the earthing switch shall be visible in the closed position through transparent covers. Mechanical interlocking systems shall prevent access to the operating shaft to avoid all operator errors such as closing the earthing switch when the LBS or CB is closed.

12. Circuit-breaker

The circuit breakers shall have 3 positions: open-disconnected, closed and earthed and shall be constructed in such a way that natural interlocks prevent all unauthorized operations. Closing and opening operation of the Circuit Breaker shall be done from remote by using shunt trip coil. Spring charging shall be done with motorized spring operating mechanism. The circuit breaker shall be fitted with a mechanical indicator on the panel front facia for indicating VCB ON/OFF positions.

It shall be fitted with a local system for manual tripping by an integrated push button. There shall be no automatic reclosing. The position of the power and earthing contacts shall be clearly visible on the front of the switchboard. The position indicator shall provide positive contact indication in accordance with relevant standards. The circuit shall be associated with an integrated protection unit that will operate without any auxiliary power supply and shall include:

a) Three toroid transformers;
b) Self-powered microprocessor relay supplied should be compatible to communicate to FRTU/SCADA equipment on MODBUS protocol;
c) A low energy release;
d) A "fast-on" test receptacle for protection testing (with or without CB tripping);
e) The protection system will ensure circuit breaker tripping as of a minimum operating current (Is) which is the rated current of the underground network to be protected and maybe set to following ratings from 10 A to 600 A.
Following settings shall be available:

Range 1 - 10 to 50 A
Range 2 - 40 to 200 A
Range 3 - 63 to 312 A
Range 4 - 250 to 600 A

f) The phase and earth fault protection shall have two separately adjustable settings;
g) Interlocking of RMU panels i.e. for breaker panel and cable compartments must be designed according to IEC 62271-200;
h) The rated operating sequence shall be O-3min-CO-3 min-CO;
i) The Circuit Breaker shall be provided with a motorized operating mechanism that can be remotely monitored and controlled from the SCADA;
j) The arc quenching medium for interrupter shall be either of SF6 or Vacuum;
k) The MAKEs of the interrupter of the CB shall be restricted to following brands:
    - ABB
    - SIEMENS
    - Schneider
    - L & T

The interrupter Makes is restricted to the brand as mentioned above and bidders are to quote accordingly. The Item/lots for which brands are restricted, no alternative/ substitute brand shall be accepted and shall be considered as non-responsive for that particular item/lot.

13. Cable Compartment

The ring main units must be equipped with the outer cone connection bushings in compliance with DIN 47 636, part 6 with M-16 inside thread. The cover of cable compartment should not be of bolted type. The access to the cable compartment shall be available preferably from the front side apart from any other access as per the manufacturer's design.

The connection points of each outgoing feeder must be horizontally situated in one level at a height of approximately 700mm starting from the bottom of the unit. The cable boxes shall be suitable for connection of 3 CORE HV XLPE cables of assorted sizes up to 400 Sq. mm.

Connecting possibilities for angle plugs and T plugs shall be provided. Cable brackets inside the cable connecting compartments must be vertically and horizontally adjustable. The cable compartment shall be arc resistant as per IEC 62271-200 amended up to-date. The internal arc fault test on cable compartment shall be carried out as per IEC. The degree of protection for cable covers shall be IP 3X. The cable bushings inside the cable compartment shall have the minimum clearances as follows:

Parameters	**unit**		**33 kV**
Air insulation of cable bushings* • Phase to Phase • Phase to Earth	mm		 350 222
Basic Insulation Level of cable bushings * • Lightning impulse voltage • Power frequency voltage	kVp kV rms		 170 70

**Above values are the standard values at 1000 meters ASL. For installing at an altitude higher than 1000 m, the insulation withstand level of external insulation and the clearances shall be corrected in accordance with relevant standard for the altitude of the site.*

14. Cable Bushings

The units shall be fitted with the standardized bushings that comply with IEC standard. All the bushings shall be at the same height from the gland plate and shall be protected by a cable boot. Necessary suitable cable boots shall be supplied as a part of RMU.

15. Voltage indicator lamps and phase comparators

Each function shall be equipped with a fixed type voltage indicator box on the front of the device to indicate whether or not there is voltage in the cables. The capacitive dividers will supply low voltage power to the lamps. Three inlets can be used to check the synchronization of phases. This device shall be in compliance with IEC 61243-5 standard.

16. Fault Passage Indicators (FPIs)

FPI shall be provided per Isolators (LBS). The device should be in compliance with IEC 61869-2 standard. These shall facilitate quick detection of faulty section of line. The fault indication may be on the basis of monitoring fault current flow through the device. The unit should be self-contained requiring no auxiliary power supply. The FPI shall be integral part of RMU and shall have LCD/LED display, automatic reset facility. They shall be fully field-programmable for earth fault and phase to phase fault. It shall also have potential free contracts for SCADA.

17. Front plate

The front plate shall have an IP2X degree of protection. The front shall include a clear mimic diagram which indicates the different functions. The position indicators shall give a true reflection of the position of the main contacts. They shall be clearly visible to the operator. The lever operating direction shall be clearly indicated in the mimic diagram. The manufacturer's plate shall include the switchboard's main electrical characteristics.

18. RMUs Motors

a) RMUs must be fitted with motors to operate LBS and circuit-breaker functions. The motors shall be provided in the RMU and shall be, 24 V, DC Motor (with smooth mechanical operation/ prefer electrical operation);
b) Installation on site shall be possible with the RMU fully energized and manufacturer should provide detailed instructions for installation to the control mechanism. Auxiliary contacts for remote indication of switch status are also required;
c) The fitting of the motors to the mechanism must not in any way impede or interfere with the manual operation of the switches. An auxiliary contact to prevent motorized operation of the mechanism while the operating handle is inserted into the operating point must also be provided;
d) A 24V battery (2 nos. 12V battery) shall be provided with at least 1 hour backup;
e) The RMU shall be provided with potential-free contacts and control contacts for DI/DOs to be interfaced with FRTU so that the RMU is capable of being monitored and controlled by SCADA/DMS.

19. Battery Charger

The battery charger shall have input voltage of 230V AC, 50Hz and output voltage of 24V DC. Battery shall be sealed maintenance free, lead acid 12V batteries of two numbers.

20. HT Current Transformer and Potential Transformer (Metering & Protection)

The RMU shall be provided with 2 core HT epoxy cast resin type CTs for metering and protection. The CT ratio, accuracy class and burden shall be as follows:

Voltage	Parameters	Functions	
		Metering	Protection
33 kV	Ratio	As per SLD	As per SLD
	Accuracy	0.5s	5P10
	Burden	15	2.5 VA

21. Space Heater

Space heater should be provided in the HV cable termination compartment with thermal sensors. The space heater shall be 230 V, 15 Watt with thermostat.

22. Tests

Following type test shall be submitted and the type test report should have been carried out within 5 years from the date of opening of the tender.

- Power frequency and Impulse withstand test of the complete RMU Unit;
- Temperature-rise test of the completed RMU Unit,
- Short-time withstand current and duration test of the complete RMU Unit,
- Mechanical operation test on breakers,
- Degree of protection test for each compartment,
- Making and breaking test of an apparatus i.e. Circuit Breaker, Load Breaker Switch & Earthing
- Switches.
- Internal arc withstand test for main tank and cable compartment inside the enclosure
- Partial discharge test for complete RMU unit
- Pressure withstand test

Acceptance and routine tests shall include the following:

- Withstand voltage at power frequency for all current carrying parts including wiring.
- Measurement of resistance of the Main circuit.
- Gas leakage Test.
- Partial Discharge test.
- Withstand voltage on Auxiliary Circuit.
- Operation of Function Locks, interlocks, Signaling Devices and Auxiliary Devices.
- Suitability & correct operation of Protection, Control Instruments and electrical connections of the circuit breaker operating mechanism (Primary & Secondary Injection).

1 General Specifications

1.1 General

This specification covers minimum requirement for design, manufacture, testing and supply of unitized/packaged substation which shall be used for outdoor and indoor installation, non-walk in type. It should essentially include:

- The enclosure of the unitized substation which shall be sized to house ring main unit (RMU)
- Transformer
- LV switch board
- HT meters with CT PT and
- Other operating accessories

1.2 Applicable Standard

Unless otherwise specified elsewhere in this specification, the equipment should be designed, manufactured and tested in compliance with the latest revision and amendments thereof of the following standards:

Device	Description	Standards
Switchgear	General Requirement for Metal Enclosed Swtichgears and control gears	IEC 62271 - 1 IEC 62271-200
Enclosure	HV / LV prefabricated substation	IEC62271-202/IEC 61330
Devices	Circuit Breaker	IEC 62271-100
	Load Break Isolator & Earthing switches	IEC 62271 - 102
	Voltage detecting systems	IEC 61243 - 5
	HT meters	IEC 60687, IEC 61036, IEC 61268, IEC 61107
Degree of protection	Degree of protection provided by enclosures (IP code)	IEC 60 529
SF6 Gas	Specification and acceptance of new Sulphur hexafluoride	IEC 60376
Insulation Coordination	Definitions, Principles and Rules	IEC 60 071-1
Instrument Transformers	Current Transformers	IEC 60 044-1
	Voltage Transformers	IEC 60 044-2
Transformer	Distribution transformers Noise level	IEC 76 (1-5) & IS 1180 IEC 551

Insulating Oil for Transformers	Mineral oils	IEC 296
LV Switchboard	LV switchgear and control gears assemblies	IEC 439-1
HT Energy Meter	Electricity Metering Equipment (AC)-General Requirements, tests and test conditions	IEC 62052-11:2003
	Class 0.5 alternating current watt hour meter	IEC 62053-22:2003
	AC STATIC WATIHOUR METERS, CLASS 0.5 AND 0.2 - SPECIFICATION	IS 14697
	Standardization of AC Static Electrical Energy Meter	CBIP 325
	Polycarbonate Moulding and Extrusion Materials.	IS 14434 (1998)
	Electricity Metering Equipment (AC)-General Requirements, tests and test conditions	IEC 62052-11:2003

1.3 Service condition

- The general operating temperature shall be from -10°C to +40°C.
- Manufacturer shall declare whether the RMU is able to operate in air temperature higher than +40 °C and confirm that current de-rating is not necessary.
- The RMU shall be capable of being exposed to high relative humidity and ambient air pollution.

1.4 System Parameters

Description	**Parameters**
Voltage	**33 kV**
Network	Three phases – Three wires
Rated Voltage	36 kV
Service Voltage	33 kV
System Frequency	50 Hz
Lightning Impulse withstand Voltage	170 kV (p)*
Power Frequency withstand voltage	70 kVrms*
Rated Normal Current	630 A
Rated Short time withstand current kArms (3Sec)	20 kA (Minimum)

Rated breaking current (kA rms)	20 kA
Rated making current (kAp)	50 kAp

** For installations at an altitude higher than 1000 m, the insulation withstand level of external insulation (i.e. phase-phase, phase-earth clearances of cables, BIL of CTs & PTs) at the service location shall be determined by multiplying the rated insulation levels by a factor Ka in accordance with figure 1 of IEC 62271-1 standard. The calculation of design parameters considering altitude correction factor shall be the responsibility of the bidder in accordance with an altitude of installation site.*

1.5 Outdoor Enclosure of USS

- The enclosure shall be made of hot dip galvanized steel sheet with minimum 2 mm thickness tropicalized to extreme weather Conditions. The preferred color shall be RAL 7032.
- The sheet shall be with polyurethane rust proof paint (80 microns)
- The powder coated metal base shall be at least made of 4mm hot dip galvanized steel and should ensure rigidity for easy transport and installation.
- The structure of the substation shall be capable of supporting the gross weight of all equipment.
- The roof of the substation compartment shall be designed to support loads up to 250 kg/m^2 and be slanted to 20°
- Intermediate ceiling roof shall be provided. A minimum clearance shall be left between the top of any component installed in the substation and the roof of the substation.
- Degree of Protection for the MV and LV compartment shall not be less than IP 54 and transformer compartment should not be less than IP 23D.
- Ventilation apertures at transformer compartment shall be provided for natural ventilation (Class K10).
- RMU and LV compartments shall be accessible on the sides of the substation through double doors equipped with key lock, and rubber seals. The doors shall be suitable for padlocking and/or lock protected. The transformer compartment shall be accessible from one of the sides. Bolted type opening door is not acceptable.
- The outgoing of the distribution transformer is to be connected directly to the incomer of the LV switchboard through busbars.
- All metallic compartments shall be earthed to a common earthing point.
- Internal lighting to be activated by associated switch for each compartment.
- The substation enclosure shall have a name plate details bearing company name, transformer capacity, name of the manufacturer and the year of manufacturing.
- Internal Arc classification and Test of the enclosure with transformer and RMU fitted shall be of IAC A FLR as per IEC.

- The top/roof of the enclosure shall be slightly tilted to 20° to avoid accumulation of water.

2 RING MAIN UNIT

The RMU shall be of extensible type for future expansion and shall consist of either circuit breaker feeders or LBS feeders or combination of both. The number of ways (feeders) of RMU and feeder configuration shall be mentioned in BOQ. The RMU shall be of single bus bar SF6 gas insulated indoor metal enclosed type and shall be suitable for installation in severe outdoor environmental conditions.

2.1 SCADA compatibility of RMUs

The RMUs shall be suitable for remote operation i.e. All the functions within the RMU (circuit Breakers / LBS) shall be fitted and supplied with motorized operation. The RMU should be provided with provision of necessary terminal blocks which shall be used for connecting the RTUs/FRTUs for automations. The RMU should have compatibility with IEC – 104 SCADA system and suitable to indicate ON/OFF position of CB, Earth Switch, Gas pressure, RMU door open, common power supply healthy, spring charges status, FPI indication and etc. All analog data from RMU (viz. from relay, meters etc.) should be available in an open protocol format for integration to SCADA through RTUs or FRTUs.

2.2 Switch Board Requirement (Main Tank)

The RMU shall meet the criteria for compact, metal-enclosed indoor switchgear in accordance with IEC 62271-200. The main tank of the RMU shall include, within the same stainless steel / metallized epoxy enclosure, the number of MV functional units required for connection and power supply, the circuit breaker feeders, LBS feeders and earthing switches. The SF6 gas tank shall be made of TIG welded stainless steel to have the best welded quality. The gas cubicle shall be metal enclosed with stainless steel of minimum 2 mm thickness and should be provided with a pressure relief arrangement away from the operator. The gas tank shall be of completely welded construction.

The switchgear and bus bar enclosure shall be filled with SF6 at 0.2 bar to 0.8 bar relative pressure to ensure the insulation and breaking functions. Sealed for life, the enclosure shall meet the "sealed pressure system" criterion in accordance with the IEC 62271 – 200 standard, a system for which no handling of gas is required throughout 30 years of service life. So, refilling valve is not required. In addition, manufacturer shall confirm that maximum leakage rate is lower than 0.1 % / year. The SF6 gas pressure inside the tank shall be constantly monitored by providing appropriate indicator (green and red pressure zones) on the front side of the panel. The tank shall be of stainless steel sheet of minimum 2.5 mm thickness and shall have IP67 protection index. The tank shall be able to withstand an accidental internal overpressure of at least 2.2 bars and suitable pressure withstand test report should be submitted with the bid. Also

the bursting pressure of the tank should not be less than 5.5 bars. Any accidental over pressure inside the sealed chamber shall be limited by the opening of a pressure-limiting device in the rear or bottom part of the enclosure. Gas will be released to the rear of the switchgear away from the operator. All the manual operations should be carried out on the font of the switchgear.

Each switchboard shall be identified by an appropriately sized label which clearly indicates the functional units and their electrical characteristics. The tank shall be of internal arc classification of IAC A and type tested for internal arc tests as per IEC on front, lateral and rear side.

2.3 Dielectric Medium

SF6 gas shall be the dielectric medium for RMUs. SF6 gas used for the filling of the RMU shall be in accordance with IEC 376. There shall be an absorption material fitted inside the tank to absorb the moisture from the SF6 gas and to regenerate the SF6 gas following arc interruption.

2.4 Bus bars

Bus bars shall consisted of three numbers of EC grade tinned copper of current rating 630 Amps. The Short time rating current shall be 20 kA for 3 seconds for 11 kV and 33 kV system. The Bus bar connections shall be of anti-oxide greased.

2.5 Load Break Switches (LBS)

The LBS provided must be fully insulated by SF6 gas. The operating mechanism shall be spring assisted mechanism with operating handle for ON /OFF. All the mechanical interlocking must also work when the LBS are operated by motor drive. The earth switch shall be naturally interlocked to prevent the main and earth switch being switched 'ON' at the same time. The selection of the main and earth switch is made by a lever on the facia, which is allowed to move only if the main or earth switch is in the off position. Each LBS shall be of the triple pole (open-disconnected, closed and earthed). The rated current of LBS shall be 630 Amps continuous at maximum ambient temperatures. Motor is to be provided for spring charging mechanism along with suitable battery and its charger. The LBS shall be provided with a motorized operating mechanism that can be remotely monitored and controlled from the SCADA.

2.6 Earthing Switches

There shall be continuity between the metallic parts of the switch board and cables so that there is no electric field pattern in the surrounding air, thereby ensuring the safety of people. The substation frames shall be connected to the main earth busbar without dismantling any busbar.
Earthing of the main circuit: The cables shall be earthed by an earthing switch with short-circuit making capacity, in compliance with IEC 62271-2 standard. The earthing switch can only be operated when the switch is open.
The earthing switch shall be fitted with its own operating mechanism and manual closing shall be driven by a fast-acting mechanism, independent of operator action. The moving contacts of

the earthing switch shall be visible in the closed position through transparent covers. Mechanical interlocking systems shall prevent access to the operating shaft to avoid all operator errors such as closing the earthing switch when the LBS or CB is closed.

2.7 Circuit-breaker

The circuit breakers shall have 3 positions: open-disconnected, closed and earthed and shall be constructed in such a way that natural interlocks prevent all unauthorized operations. Closing and opening operation of the Circuit Breaker shall be done from remote by using shunt trip coil. Spring charging shall be done with motorized spring operating mechanism. The circuit breaker shall be fitted with a mechanical indicator on the panel front facia for indicating VCB ON/OFF positions.

It shall be fitted with a local system for manual tripping by an integrated push button. There shall be no automatic reclosing. The position of the power and earthing contacts shall be clearly visible on the front of the switchboard. The position indicator shall provide positive contact indication in accordance with relevant standards. The circuit shall be associated with an integrated protection unit that will operate without any auxiliary power supply and shall include:

a) Three toroid transformers;
b) Self-powered microprocessor relay supplied should be compatible to communicate to FRTU/SCADA equipment on MODBUS protocol;
c) A low energy release;
d) A "fast-on" test receptacle for protection testing (with or without CB tripping);
e) The protection system will ensure circuit breaker tripping as of a minimum operating current (Is) which is the rated current of the underground network to be protected and maybe set to following ratings from 10 A to 600 A.
   Following settings shall be available:

   Range 1 - 10 to 50 A
   Range 2 - 40 to 200 A
   Range 3 - 63 to 312 A
   Range 4 - 250 to 600 A

f) The phase and earth fault protection shall have two separately adjustable settings;
g) Interlocking of RMU panels i.e. for breaker panel and cable compartments must be designed according to IEC 62271-200;
h) The rated operating sequence shall be O-3min-CO-3 min-CO;
i) The Circuit Breaker shall be provided with a motorized operating mechanism that can be remotely monitored and controlled from the SCADA;
j) The arc quenching medium for interrupter shall be either of SF6 or Vacuum;
k) The MAKEs of the interrupter of the CB shall be restricted to following brands:
   - ABB
   - SIEMENS
   - Schneider

- L & T

The interrupter Makes is restricted to the brand as mentioned above and bidders are to quote accordingly. The Item/lots for which brands are restricted, no alternative/ substitute brand shall be accepted and shall be considered as non-responsive for that particular item/lot.

2.8 Cable Compartment

The ring main units must be equipped with the outer cone connection bushings in compliance with DIN 47 636, part 6 with M-16 inside thread. The cover of cable compartment should not be of bolted type. The access to the cable compartment shall be available preferably from the front side apart from any other access as per the manufacturer's design.

The connection points of each outgoing feeder must be horizontally situated in one level at a height of approximately 700mm starting from the bottom of the unit. The cable boxes shall be suitable for connection of 3 CORE HV XLPE cables of assorted sizes up to 400 Sq. mm.

Connecting possibilities for angle plugs and T plugs shall be provided. Cable brackets inside the cable connecting compartments must be vertically and horizontally adjustable. The cable compartment shall be arc resistant as per IEC 62271-200 amended up to-date. The internal arc fault test on cable compartment shall be carried out as per IEC. The degree of protection for cable covers shall be IP 3X. The cable bushings inside the cable compartment shall have the minimum clearances as follows:

Parameters	**unit**	**33 kV**
Air insulation of cable bushings* • Phase to Phase • Phase to Earth	mm	 350 222
Basic Insulation Level of cable bushings * • Lightning impulse voltage • Power frequency voltage	kVp kV rms	 170 70

**Above values are the standard values at 1000 meters ASL. For installing at an altitude higher than 1000 m, the insulation withstand level of external insulation and the clearances shall be defined by the bidder considering altitude correction factor in accordance with altitude of installation site.*

2.9 Cable Bushings

The units shall be fitted with the standardized bushings that comply with IEC standard. All the bushings shall be at the same height from the gland plate and shall be protected by a cable boot. Necessary suitable cable boots shall be supplied as a part of RMU.

2.10 Voltage indicator lamps and phase comparators

Each function shall be equipped with a fixed type voltage indicator box on the front of the device to indicate whether or not there is voltage in the cables. The capacitive dividers will supply low

voltage power to the lamps. Three inlets can be used to check the synchronization of phases. This device shall be in compliance with IEC 61243-5 standard.

2.11 Fault Passage Indicators (FPIs)

FPI shall be provided per Isolators (LBS). The device should be in compliance with IEC 61869-2 standard. These shall facilitate quick detection of faulty section of line. The fault indication may be on the basis of monitoring fault current flow through the device. The unit should be self-contained requiring no auxiliary power supply. The FPI shall be integral part of RMU and shall have LCD/LED display, automatic reset facility. They shall be fully field-programmable for earth fault and phase to phase fault. It shall also have potential free contacts for SCADA.

2.12 Front plate

The front plate shall have an IP2X degree of protection. The front shall include a clear mimic diagram which indicates the different functions. The position indicators shall give a true reflection of the position of the main contacts. They shall be clearly visible to the operator. The lever operating direction shall be clearly indicated in the mimic diagram. The manufacturer's plate shall include the switchboard's main electrical characteristics.

2.13 RMUs Motors

a) RMUs must be fitted with motors to operate LBS and circuit-breaker functions. The motors shall be provided in the RMU and shall be rated single phase, 24 V, DC Motor (with smooth mechanical operation/ prefer electrical operation);
b) Installation on site shall be possible with the RMU fully energized and manufacturer should provide detailed instructions for installation to the control mechanism. Auxiliary contacts for remote indication of switch status are also required;
c) The fitting of the motors to the mechanism must not in any way impede or interfere with the manual operation of the switches. An auxiliary contact to prevent motorized operation of the mechanism while the operating handle is inserted into the operating point must also be provided;
d) A 24V battery (2 nos. 12V battery) shall be provided with at least 1 hour backup;
e) The RMU shall be provided with potential-free contacts and control contacts for DI/DOs to be interfaced with FRTU so that the RMU is capable of being monitored and controlled by SCADA/DMS.

2.14 Battery Charger

The battery charger shall have input voltage of 230V AC, 50Hz and output voltage of 24V DC. Battery shall be sealed maintenance free, lead acid 12V batteries of two numbers.

2.15 HT Current Transformer and Potential Transformer (Metering & Protection)

The RMU shall be provided with 2 core HT epoxy cast resin type CTs for metering and protection. The CT ratio, accuracy class and burden shall be as follows:

Voltage	Parameters	Functions	
		Metering	Protection
33 kV	Ratio	As per SLD	As per SLD
	Accuracy	0.5s	5P10
	Burden	2.5VA	2.5 VA

2.16 Space Heater

Space heater should be provided in the HV cable termination compartment with thermal sensors. The space heater shall be 230 V, 15 Watt with thermostat.

2.17 Tests

Following type test shall be submitted and the type test report should have carried out within 5 years from the date of opening of the tender.

- Power frequency and Impulse withstand test of the complete RMU Unit;
- Temperature-rise test of the completed RMU Unit,
- Short-time withstand current and duration test of the complete RMU Unit,
- Mechanical operation test on breakers,
- Degree of protection test for each compartment,
- Making and breaking test of an apparatus i.e. Circuit Breaker, Load Breaker Switch & Earthing
- Switches.
- Internal arc withstand test for main tank and cable compartment inside the enclosure
- Partial discharge test for complete RMU unit
- Pressure withstand test

Acceptance and routine tests shall include the following:

- Withstand voltage at power frequency for all current carrying parts including wiring.
- Measurement of resistance of the Main circuit.
- Gas leakage Test.
- Partial Discharge test.
- Withstand voltage on Auxiliary Circuit.
- Operation of Function Locks, interlocks, Signaling Devices and Auxiliary Devices.
- Suitability & correct operation of Protection, Control Instruments and electrical connections of the circuit breaker operating mechanism (Primary & Secondary Injection).

3 DISTRIBUTION TRANSFORMERS

3.1 General

Transformers shall be restricted **to Marson's Electrical Industries, India ; Kanohar Electrical Ltd., India; Nucon Switchgear Ltd., India; Kotsons Pvt. Ltd., India ; NEEK, Nepal ; Uttam Bharat, India ; Universal Power Transformer, India ; Kirloskar Electrical Company, India ; Schneider Electric Infrastructure Limited, India brands only.**

Transformers shall be oil-immersed type hermetically sealed with corrugated tank for indoor use. It shall have electrostatic screen which shall be earthed.

3.2 Transformer Weights and Special Bracing of Windings

Transformer winding shall be so braced / fitted internally to protect the windings against excessive movement and vibration during transportation and particularly during hand carriage to the site.

3.3 Packing

Where applicable, transformers shall be delivered filled with oil and supplied with all accessories mounted or installed. Gaskets and bolts shall be correctly installed or tightened, to ensure no leakage of oil.

3.4 Capitalization of losses for the bid evaluation

The fixed (iron) and running (copper) losses shall be as low as possible, consistent with reliability and economical use of materials. The supplier shall provide the guaranteed values of losses in the Schedule of Guaranteed Technical Particulars enclosed with the Bid document. Maximum losses and percentage impedance of the transformer should be as follows:

Sl #	DESCRIPTION	Max losses (kW)	
		No load Losses	Load Losses
1	33/0.415 kV, 750 kVA	1.20	10.00

Bidders are to design the transformer based on the above losses only and no tolerance will be permitted beyond the above values. Those bidders who do not meet the above losses will be out-rightly rejected.

3.5 Technical Specification

This specification represents the minimum requirements for the works. The Supplier shall provide equipment, which meets or exceeds these minimum requirements. These items are being sought as additions to existing networks; it is essential to maintain compatibility with existing hardware and line design, as well as with established local work practices and methods.

3.6 Technical Parameters

3.6.1 Ratings

The distribution transformers shall be rated as given in the price schedule.

3.6.2 Operating Characteristics

In addition to the common technical requirements specified, the following minimum operating characteristics shall apply to all the distribution transformers covered in this Specification:

Sl. No	Characteristics	Unit	Parameters
1	Type	-	Oil-filled
2	Secondary voltage (no load)	V	415 V
3	Vector group	-	Dyn11 with solidly earthed neutral
4	Rated frequency	Hz	50
5	Number of phases	Ph	3
6	Type of tap changer link	-	Off circuit link
7	Off-load tapping (primary side)	%	-5 to +5
8	Tap Step	%	-2.5 to +2.5
9	Short circuit impedance voltage at 75°C	%	4 % to 5 %
10	Materials of conductor	-	Electrical Grade Copper
11	Cooling type	-	ONAN
12	Insulation class (IEC 76)	-	A
13	Maximum winding temperature rise	°C	40
14	Maximum top oil temperature rise with conservator	°C	50
15	Maximum allowable noise level		As per IEC 551
16	Type of terminal connection		
a)	HV Side		Suitable to connect to RMU with adequate rating
b)	LV Side		Suitable to connect to ACB with adequate rating
c)	Secondary neutral end		One bushing each inside and outside cable box
17	Windings		
a)	One minute power frequency withstand voltage (dry & wet)	kV (rms)	33 kV 70
b)	1.2/50µs full wave impulse withstand voltage	kV (peak)	170
18	*Minimum clearance between Bushings		
a	HV: Phase –Phase & Phase -Earth	mm	350/222

b	LV: Phase –Phase & Phase -Earth	mm	25/20
19	Painting		Power coated
20	Colour		RAL 7032

** For installations at an altitude higher than 1000 m, the insulation withstand level of external insulation (i.e. phase-phase, phase-earth clearances of cables, BIL of CTs & PTs) at the service location shall be determined by multiplying the rated insulation levels by a factor Ka in accordance with figure 1 of IEC 62271-1 standard.*

3.6.3 Construction

The core shall be constructed from M4 grade cold rolled, non-ageing, grain oriented silicon sheet steel having maximum of 1.11watt/kg. The primary and secondary windings shall be constructed from super enamelled insulated high conductivity copper. All turns of windings shall be adequately supported top and bottom, to prevent movement. In cases where turns are spaced out, a suitable inter-turn packing shall be provided. The insulation between core and bolts and core and clamps shall withstand 2,000V for one minute.

All steel sections used for supporting the core shall be thoroughly shot or sand blasted after cutting, drilling and welding. Core laminations shall be annealed and burrs removed after cutting. Cut edges shall be insulated. The framework and clamping arrangements of core and coil shall be securely earthed inside the tank by a copper strap connected to the tank. The core clamping structure shall be design to minimize the eddy current loss. The core shall be provided with lugs suitable for lifting the complete core and coil assembly.

No material which can be deleteriously affected by the action of oil under the operating conditions of the transformers shall be used in the transformers or leads or bushings.

3.6.4 Transformer tank and covers

The transformer tank and covers shall be fabricated from high-grade sheet steel and shall be of robust construction. All seam, flanges, lifting lugs, braces, and other parts attached to the tank shall be welded.

Tanks with corrugations shall be tested for leakage test at a pressure of 0.15kg/ sq. cm measured at the top of the tank. All matching faces of joints to be made oil tight shall be finished with a smooth surface to ensure that the gasket material will make a satisfactory joint. Bolts shall be spaced at sufficiently close intervals to avoid buckling of either flange or covers and provide reasonably uniform compression of the gasket.

Each transformer shall be provided with a minimum of two closed lifting lugs. The minimum diameter of the hole or width of the slot shall be 25 mm. The two lifting lugs shall be so located

that there will be a minimum clearance of 100 mm between the lifting chain and the nearest part of the bushings.

Tank shall be provided with a pressure release device, which shall operate at a pressure below the test pressure for tank and radiators. The device shall be provided with device visible from ground to indicate operation. The device shall be provided with potential free contacts for alarm and tripping. Alternatively, a separate pressure relay shall be provided for this purpose.

3.6.5 Transformer Sealing

For sealed units, a satisfactory lid sealing gasket shall be provided on each of these transformers to maintain the seal at extremes of operating temperature. A cold oil level mark shall be provided inside each transformer marked C.O.L.

3.6.6 Internal and external finish

Internal and external tank and radiator surfaces shall be thoroughly cleaned by shot blasting or be given an acid and phosphate dip treatment to remove rust and scale and to provide an adherent, moisture resistant coating. Due care shall be given to avoid over pickling, resulting in pitting or unduly heavy deposit of phosphate. This resultant coating shall provide a surface, which shall offer good paint adhesion and a resistance to corrosion. The interior surfaces of the tank and cover above the lowest oil level shall be given one coat of oil and acid resisting paint, after cleaning.

The exterior surfaces of the complete transformer shall, where appropriate, be protected by a paint system which shall be applied strictly in accordance with the paint manufacturer's instructions. The system shall consist of not less than two priming coats and two finishing coats of oil and weather resisting paint.

The total thickness of the paint shall be not less than 0.120 mm with a minimum total thickness of priming and finishing paint of 0.06 mm each. Attention shall be paid to the need to achieve adequate coverage at metal edges, where breakdown of the paint film often begins. The paint system and the colour of the final coat shall be RAL 7032.

3.6.7 Rating Plate

A stainless steel rating plate, of at least 1 mm thickness, shall be fitted to each transformer and shall carry all the information as specified in the Standards.

3.6.8 Terminal Markings

All transformers shall have the primary and secondary terminal markings plainly and indelibly marked on the transformer adjacent to the relevant terminal.

3.6.9 Terminal Leads

Outgoing leads shall be specially supported, to withstand the effects of vibration and handling during transport, hand cartage and short circuits.

Air filled cable boxes if provided shall be of adequate dimensions and designed in such a manner that they can be opened for inspection without disturbing the incoming cable.

The provision shall be made for earthing the body of each cable box and Cable box shall be complete with necessary glands, lugs and armour grips.

3.6.10 Bushings

All bushings shall be porcelain clad, and shall be sealed to prevent ingress of moisture and to facilitate removal. The neutral bushings and stems shall be identical to those provided for phase terminations. Bushing palms shall be made of brass and have one 14 mm dia. hole.

3.6.11 Earthing Connections

All internal metal parts of the transformers shall be earthed at one point only. The magnetic circuit shall be connected to the clamping structure at one point only. The frame work and clamping arrangements of core and coil shall be securely earthed by copper strip connection to the main frame and enclosure.

Two earthing connections shall be provided with connection facilities. The bolts shall be located on the lower side of the transformer and be of M12 size. Each connection shall be indicated clearly with an engraved 'earth' symbol. The transformer shall be earth to the USS body with a copper flat of suitable rating.

3.6.12 Gaskets

Gaskets provided with the transformers shall be suitable for making oil tight joints, and there shall be no deleterious effects on either gaskets or oil when the gaskets are continuously in contact with hot oil. Exterior gaskets shall be weatherproof and shall not be affected by strong sunlight/UV. The material for gaskets shall be cork, neoprene or equivalent.

3.6.13 Drying Out, Filling, Transformer Oil

All transformers shall be thoroughly dried out at the manufacturer's works. Oil immersed type transformers shall be delivered filled with oil to normal level, ready for service.

All transformers shall be filled to the required level with new, unused, clean, standard mineral oil in compliance with IEC-60296 and shall be free from all traces of polychlorinated biphenyl (PCB) compounds.

3.6.14 Fittings

All transformers shall be, as a minimum, fitted with the following:

SL. No	Description
1	Rating and diagram plate
2	Two Earthing terminals
3	Lifting lug
4	Oil temperature indicator
5	Winding temperature indicator
6	Pressure relief valve
7	Drain cum bottom filter valve with plug
8	Thermometer pocket
9	Accessories for clamping to the foundation channel in order to withstand earthquake forces.
10	HV terminals: - indoor cast resin. The manufacturer shall connect HV terminal and RMU through suitable Aluminum cable/busbar of suitable rating.
11	LV terminals: The manufacturer shall connect LV terminals by Aluminum cable/busbar of suitable rating.
12	Skid base with cross bracing
13	Externally operated off load tap switch lock and keys
14	4" dia. Thermometer
15	W.T.I and O.T.I suitably fitted and connected to the transformers.

3.6.15 Radio Interference

When operated at voltages up to 10% in excess of the normal system rating, transformers shall be substantially free from partial discharges; i.e., corona discharges in either internal or external insulation, which are likely to cause interference with radio or telephone communications.

3.6.16 Test

The type test report should have been carried out within 5 years from the date of opening the tender and following minimum type test of the transformer shall be submitted with the offer:

1. Lightning impulse and power frequency test;
2. Temperature rise test;
3. Short circuit current test;
4. Pressure test.

4 LV SWITCHBOARD

4.1 Construction Features

The LV Switch board shall be enclosed in the USS and should be smooth finished, leveled and free from wobbling.

Doors, removable covers, if any and plate shall be gasket all around with neoprene gaskets, and this is essential to prevent ingress of dust and vermin. All live parts shall be provided with at least phase to phase and phase to earth clearance in air of 25 mm and 20 mm respectively.

The construction system shall provide a complete set of elements for installing fixed or withdrawal switching and protective devices, measuring devices and control/monitoring devices in the switchboard. Approval shall be made for brought out items.

4.2 Main Busbar

Main busbar shall be of Aluminum alloy of grade E91E, conforming to relevant IEC standards.

All busbar shall be a solid strip without joints and shall be rated continuously. The maximum temperature of the busbar under operating conditions when carrying rated normal current at rated frequency should not exceed 85°C.

Busbar shall be adequately supported on insulators to withstand dynamic stresses due to short circuit current. Busbar support insulators shall conform to relevant standard IEC standards.

Busbar should not be painted and all performance characteristics specified shall be obtained with unpainted busbars.

4.3 Air Circuit Breaker (ACB)

The ACB shall be provided in the LT side of the transformer with the following parameters:

Sl. No.	Description	Unit	Particulars
1	Rated Frequency	Hz	50
2	Phase	Ph	3
3	Rated Current	Amps	1250
4	Rated operational voltage	V	415
5	Release	-	Microprocessor based
6	Breaking capacity	kA	50

4.4 Moulded Case Circuit Breaker (MCCB)

MCCBs shall be heavy duty type, mounted on bases, having a rupturing capacity of 50kA at 415V A.C. 50 Hz. Incoming MCCBs are to be supplied and installed as part of the completed LV

switchboard with the following parameters:

Sl. No.	Description	Unit	Particulars
1	Rated Frequency	Hz	50
2	Phase	Ph	3
3	Rated Current	Amps	400 (2No), 200 (4nos)
4	Rated operational voltage	V	415
5	Breaking capacity	kA	36
6	Release	-	Static (thermal overload and magnetic short circuit)
7	Type	-	Manual/Fixed
8	Altitude	m	Given in general specification

4.5 Interior Lighting of LV Switchboard

Each panel should be provided with a compact fluorescent lamp (CFL) lighting fixture (11W) or LED lamp rated for 240V, 1 phase, 50Hz supply for the interior illumination of the panel during maintenance. Switching of the fitting shall be controlled by the respective panel door switch. All CFL lamps shall be with pin type holder.

4.6 Labels

All LV Switchgear shall be provided with labels or name plates, giving a description of the equipment, together with information regarding the nominal voltage, nominal current and the like under which the item of plant in question has been designed to operate.

5 ENERGY METERS

Energy meters shall be restricted to **Actaris, Iskrameco, Solvakia, landis-Gyer, Secure Meter brands only.**

5.1 General technical requirement

- Application : 3 phase 3 wire system or 3 phase 4 wire or
- Rated Secondary Voltage : 63.5 volts (Phase to Neutral)
- Rated secondary Current (I Basic) : 1 Amps
- Rated Frequency : 50 Hz.
- Accuracy class : 0.5s as per meter category
- Power Factor : Unity to Zero (all power factor lag / or lead)
- The meter shall start and continue to register on application of 0.1% of basic current at Unity P.F., as per relevant standards and shall work satisfactorily up to maximum continuous current of 2 times rated basic current with the following supply system variation:

Voltage: Vref ± 30%

Frequency: 50 Hz ±5%

- Temperature: The standard reference temperature for performance shall be 27 °C. The mean temperature co-efficient shall not exceed 0.03%.
- The reactive accuracy class of the meter shall be same as the active accuracy class

5.2 Influence quantities

The meter should be designed and protected such that all external effects and influences shall not change its performance & shall work satisfactorily within guaranteed accuracy limits, as specified in IS 14697: 1999 / CBIP technical report – 304, under the presence of influence quantities.

5.3 Construction

The case, winding, voltage circuit, sealing arrangements, registers, terminal block, terminal cover & name plate etc, shall be in accordance with the relevant standards. The meter should be compact & reliable in design, easy to transport & immune to vibration & shock involved in the transportation & handling. The construction of the meter should ensure consistence performance under all conditions especially during storms/heavy rains/very hot weathers. The insulating materials used in the meter should be non-hygroscopic, non-ageing & have tested quality. The meter should be sealed in such a way that the internal parts of the meter become inaccessible.

The meter should employ latest technology such as Application Specific Integrated Circuit (ASIC) to ensure reliable performance. The mounting of the components on the PCB should be Surface Mounted Technology (SMT) type except some power supply related component. The electronic components used in the meter should be of high quality.

5.4 General mechanical requirements

The construction of the meter shall be rigid & suitable to withstand shock & vibration involved in transportation & handling, as specified in IS 14697. Meter shall be designed and constructed in such a way as to avoid introducing any danger in normal use and under normal conditions, so as to ensure especially personal safety against electric shook, safety against effect of excessive temperature, protection against spread of fire, protection against penetration of solid objects, dust and water. The design of meter shall conform to IP51 class degree of protection against dust and moisture as per relevant standards.

5.5 Tropical treatment

All parts, which are subject to corrosion under normal working conditions, shall be protected effectively. Any protective coating shall not be liable to damage by ordinary handling or damage due to exposure to air, under normal working conditions. Meters shall withstand solar radiation. The meters shall be suitably designed and treated for normal life & satisfactory operation under the hot and hazardous tropical climatic conditions as specified in clause no. 2. The meter shall work from -10°C to +55°C and RH 95% non-condensing type.

5.6 Meter case

The housing of the meter shall be safe high-grade Engineering plastic or any other high quality insulating material and shall be very compact in design. All the insulation materials used in the construction of meter shall be non-hygroscopic, non-ageing & of tested quality, capable of withstanding resistant to heat & fire. The construction of the meter offered shall be such that it can be sealed independently and the cover cannot be removed with the use of a tool, without breaking the seal. The case of offered meters shall be so constructed that any non-permanent deformation shall not prevent the satisfactory operation of the meter. The meter shall have a transparent cover and opaque base with seamless ultrasonic welding.

5.7 Terminals -terminal block

The base of the meter shall have a terminal block at the bottom made out of high grade engineering plastic so as to facilitate bottom connection and houses solid nickel plated brass terminals having capability to carry maximum value of current.

The material of the terminal block shall be capable of passing the tests given in IS 14697: 1999.

The terminal holes in the insulating material shall be of sufficient size to accommodate the insulation of the conductors. The diameter of the terminal hole for current terminals shall not be less than 5.0 mm & shall be of adequate length in order to have proper grip of conductors / crimping pins with the help of two screws.

The terminal block shall satisfy all the conditions such as clearance & creepage distance between terminals & surrounding part of the meter as specified in relevant clause of IS 14697: 1999.

The manner of fixing the conductors to the terminals shall ensure adequate and durable contact such that there shall have no risk of loosening or undue heating. Screw connections transmitting contact force and screw fixing which may be loosened and tightened several times during the life of the meter shall be such that the risk of corrosion resulting from contact with any other metal part is minimized. Electrical connections shall be so designed that contact pressure shall not be transmitted through insulating material.

5.8 Terminal block cover

The terminals block cover for the energy meters shall be extended transparent type, which can be sealed independently of the meter cover. The ETBC shall have a clear space of min 40±5mm, thus allowing sufficient clearance space for inserting cables. ETBC shall have a top side hinge arrangement for easy access of terminal for wire termination. The terminals, their fixing screws and the insulated compartment housing them shall be enclosed by extended terminal cover in such a way that no part of meter or accessories at terminal block shall be accessible from the front of the meter. There shall be provision of fixing of seals so that screws cannot be loosened without breaking the seals.

The terminals shall not be accessible without removing the seal(s) of terminal cover when energy meter is mounted on the meter board.

5.9 Window

The energy meter cover shall be made of high-grade engineering plastic with one window. The window shall be of transparent material ultrasonically welded with the meter cover such that it cannot be removed undamaged without breaking the meter cover seals.

5.10 Quality

Overall the quality of the meter should be good and the service life of the meter shall be more than the guarantee period. The material, components used for manufacturing the meter shall be of premium quality. The LCD display shall not fade with time and the display annunciators should be visible. Functionality of the meter shall not be affected by the harsh environmental conditions. Quality meters shall be given preference and the performance of previous installed meters shall be analyzed before awarding the tender. Aesthetically, the meter shall be of premium quality.

5.11 Communication port

5.11.1 Local communication port

The energy meter shall have a galvanically isolated IEC 1107 optical communication port located in front of the meter for data transfer to or from a hand held Data Collection Device. The sealing provision should be available for optical port.

5.11.2 Remote communication port

Meter shall have an additional communication port (RS 232) in the form of RJ11 port to interface external modem for remote data collection. RS 232 (RJ11) port shall be located under the terminal cover.

Both the ports will support communication on DLMS and should be accessible through a DLMS compliant HHU

5.12 Data downloading capability

Meter shall support a minimum baud rate of 9600 on optical port as well as RS 232 remote communication port. It shall be possible to read selective data from the meter as specified in the companion standard.

5.13 Display of measured value

The measured value(s) shall be displayed on seven segments, seven digit Liquid Crystal Display (LCD) display unit/register, having minimum character height of 10 mm.

The data should be stored in non-volatile memory. The non-volatile memory should retain data for a period of not less than 10 years under unpowered condition. Battery back-up memory will not be considered as NVM.

It should be possible to easily identify the single or multiple displayed parameters through symbols/legend on the meter display itself or through display annunciators.

Meter shall have Scroll Lock facility to display any one desired parameter continuously from display parameters.

The register shall be able to record and display starting from zero, for a minimum of 1500 hours, the energy corresponding to rated maximum current at reference voltage and unity power factor. The register should not roll over in between this duration.

The meter should display the required parameters in two different modes as follows:

(Display sequence for both auto and Push button must be maintained, no interchange in sequence or display parameter will be accepted. All the display should have proper legend to identify the same.)

5.13.1 Auto Display Mode

The following parameters should be displayed in auto cycle mode, in the following sequence. Each parameter should be on meter display for 10 seconds and the time between two auto cycles should be at 60 seconds gap.

1. LCD test
2. Total Cumulative Active Forwarded Energy in kWh(up to date)
3. Meter serial number
4. Real Date (dd mm yy)
5. Real Time (hh mm ss)
6. Present Month MD in KW and KVA since last MD reset with date and time.

Each parameter should be on meter display for 10 seconds and the time between two auto cycles should be at 60 seconds gap.

5.13.2 Push Button mode

The following parameters should be displayed on pressing the push button

1. LCD test
2. Total Cumulative Active Forwarded Energy in kWh (up to date)
3. Meter serial number
4. Real Date (dd mm yy)
5. Real Time (hh mm ss)
6. Present Month MD in KW and KVA since last MD reset with date and time.
7. Previous 3 months (at least) cumulative KWh, KVAh and Maximum Demand in KVA at 24.00 hrs. of last date of the month.
8. Instantaneous Phase Voltages
9. Instantaneous Phase Currents
10. Instantaneous Neutral Current* i.e. Actual Current flowing through the Neutral
11. Instantaneous Power Factor
12. Inst. Power Factor – Phase Wise
13. Average Power Factor (Previous Month)
14. Instantaneous Active Power
15. Instantaneous Apparent Power
16. Instantaneous Frequency
17. High resolution display for KWh, KVARH and KVAH (minimum 2+4 i.e. 4 digit after decimal
18. Phase Sequence
19. Connection check (For CT Reversal Connection Not OK)
20. Self-Diagnosis

Display for Auto and manual mode must be listed by two headers

A) Auto Display Mode and

B) Push Button Mode (Parameters should be pasted in front of the PP Box

Each parameter should be on meter display for 10 seconds and the time between two auto cycles should be at least 60 seconds gap).

5.14 Electromagnetic compatibility

The static energy meters shall conform to requirements listed in relevant standards and shall also be protected against radiated interference from either magnetic or radio-frequency source.

5.15 Immunity to electromagnetic disturbance

The meter shall be designed in such a way that conducted or radiated electromagnetic disturbance as well as electrostatic discharge do not damage or substantially influence the meter and meter shall work satisfactorily under these conditions as per relevant standards

NOTE: the disturbances to be considered are:

(a) Harmonics
(b) Voltage dips and short interruptions
(c) Conducted transients
(d) D.C. and A.C. magnetic fields
(e) Electromagnetic fields
(f) Electrostatic discharges

5.16 Radio interference suppressions

The meter shall not generate noise, which could interfere with other equipment, and meter shall work satisfactorily as per relevant standards

5.17 Influence of high magnetic field

The meters shall be provided appropriate magnetic shielding so that any external magnetic field (AC/DC electromagnet) as per CBIP Technical Report no. 304 applied on meter would not affect the proper functioning of the meter and meter shall work satisfactorily as per relevant standards.

5.18 Starting current

The meter shall start and continue to register at the current 0.1% of Ib.

5.19 Running with no load

When the 115% of rated voltage is applied with no current flowing in the current circuit, the meters shall not register any energy and test output of the meter shall not be more than one pulse/count on "no load".

5.20 Power consumption

The active and apparent power consumption in each voltage circuit of the CT Operated meters at reference voltage; temperature and frequency shall not exceed 1.0 W and 4 VA per phase respectively.

The apparent power consumption in each current circuit for the CT Operated meters at basic current, reference frequency and reference temperature shall not exceed 1.0 VA per phase.

5.21 Calibration & test output

All the meters shall be tested, calibrated and sealed at works before dispatch. Further, no modification of calibration shall be possible at site by any means.

However, it shall be possible to check the accuracy of energy measurement of the meter in the field by means of LED output on meter. Meter should have two calibration LEDs for accuracy measurement for different energies. Out of these, one should be kept fixed on kWh and other one shall be configurable for rest two (kVArh, kVAh). Resolution of the test output shall be sufficient to enable the starting current test in less than 10 minutes.

5.22 Connection diagram

The connection diagram of the meter shall be clearly shown for 3 phase 4 wire system, on the terminal cover. The meter terminals shall also be marked and this marking should appear in the above diagram.

5.23 Quantities to be measured

The meter shall be able to provide the following data in line with Category 'C' type as per IS 15959 - Indian Companion Specification.

a) Instantaneous Parameters
b) Block Profile / Load Survey data
c) Abstract quantities
   - Name Plate Details
   - Programmable parameters
d) Event Conditions
e) Billing profile parameters.
f) Time of day registers.

The meter shall be able to measure and provide the parameters listed in the guideline document. The OBIS code for each parameter shall be as identified as per DLMS /COSEM protocol in line with Indian companion standard.

5.24 Abnormality events detection

The meter should have features to detect the occurrence and restoration of, at least, the following common abnormal events:

a) **Missing Potential:** The meter shall be capable of detecting and recording occurrence and restoration with date and time the cases of Potential failure (one phase or two phases). All potential missing cases shall be considered as power failure.

b) **Current imbalance**: The meter shall be capable of detecting and recording occurrence and restoration with date and time of Current unbalance (for more than a defined persistence time).

c) **Current Reversal:** The meter shall be capable of detecting and recording occurrence and restoration with date and time if the current is flowing in reverse direction in one or more

phases. The meter shall continue to record in forwarded direction even in case of CT reversal.

d) **Power on/off**: The meter shall be capable to record power on /off events in the meter memory. All potential failure should record as power off event.

e) **Magnetic Influence** - The Meter shall be capable of detecting and recording of presence of abnormal magnetic influence near the meter, if the magnetic influence affects the meter functionality. The meter should record at Imax on account of magnetic influence. Separate legend for magnet event shall be made available on LCD. This legend shall remain in on state till meter reading so that it will come in to notice of meter reader.

f) **Voltage unbalance** – Meter shall detect voltage unbalance if there is unbalance in voltages.

g) **Over Current** – When load condition at any phase i.e. Line current at any phase goes more than defined limit , this will be detected as Over current condition.

h) **CT Open** – The meter should detect phase wise current circuit open when the circuit is opened from meter side.

i) **CT Bypass** – The condition should be detected whenever the current terminal is bypassed in the meter

j) **Neutral Disturbance** – The meter should detect neutral disturbance if any spurious signal is applied at the meters neutral.

k) **High and Low Voltage**: The meter should detect under and over voltage events respectively if voltage falls / rise from defined limits.

l) **Cover Open**: The meter shall be able to detect cover open occurrence event if cover is opened in mains on or off condition. Separate legend for cover open event shall be made available on LCD. This legend shall remain in on state till meter reading so that it will come in to notice of meter reader

The above shall be selectable and will be in line with IS 15959: Data Exchange for Electricity Meter Reading, Tariff and Load Control – Companion Specification

The meter shall keep records for the minimum last 300 events (occurrence + restoration) for above abnormal conditions. Each event shall be logged with date and time of occurrence/restoration with snapshot of voltage, current power factor and active energy (except cover open, power on-off). It shall be possible to retrieve the abnormal event data locally using a hand held unit (HHU) through the meter's optical port & same can be viewed / analysed at base computer end in simple and easily understandable format.

5.25 Abnormal voltage/frequency device test

The accuracy of the meter would not be affected with the application of abnormal voltage/ frequency generating device having spark discharge of approximately 35KV. The meter will be tested by feeding the output of this device to meter in any of the following manner for 10 minutes:

i) On any of the phase or neutral terminals.
ii) On any connecting wires of the meter.
iii) Voltage discharge with 0-10 mm spark gap.
iv) Spark on meter body.
v) Spark on the optical and RS 232 port.
vi) At any place in load circuit.

The accuracy of the meter will be checked before and after the application of above device.

5.26 Load survey

Meter should support parameters as mentioned IS-15959 for Category "C" .

Following parameters shall be made available for last 60 days with integration period of 15 min. Out of which the utility should be able to select any five parameters

- Real time clock, date and time.
- Current, Ir
- Current, Iy
- Current, Ib
- Voltage ,V Rn
- Voltage ,V Yn
- Voltage ,V Bn
- Active forwarded Energy
- Reactive lag forwarded energy
- Reactive lead forwarded energy
- Apparent Energy

These load survey can be retrieved with the help of Meter Reading Instrument on local interrogation or remotely using the remote communication interface.

5.27 Maximum demand

The meter should be capable of recording the Apparent/Active MD in kVA/kW with integration period of 15 minutes. Itcommence at the fixed time intervals of the real time mustbe provided. 12 (twelve) months back up data for KWH, KVARH (lag and lead), KVAH and MD in KVA with date and time should be available in BCS.

5.28 MD reset option

1. Billing Date at 12:30 Hrs (Bhutan Standard Time) (Programmable) first day of the month.

2. Push button
3. By Authenticated Command from BCS through HHU or directly from PC/REMOTE
4. MD reset button should have proper sealing arrangement. Specific Operation should be available in downloaded data.

5.29 Time of day registers

The meter shall have support of eight TOD registers and rate registers for demand and energy monitoring in peak and off peak time zones. TOD rate and MD registers are required for active and apparent energy channels.

5.30 Billing Parameters

The meter shall generate these parameter for each billing cycle and should store in the memory. The set of data for last 12 cycles shall be stored in the memory. And the parameter should be as per table 29 of IS-15959.

5.31 Self-diagnostic feature

The meter shall be capable of performing complete self-diagnostic check to monitor the circuits for any malfunctioning to ensure integrity of data memory location at all time. The meter shall have indication for unsatisfactory/non-functioning/malfunctioning of the following:

a) Time and date on meter display
b) All display segments on meter display
c) Self-diagnostic (RTC, NVM information) on display

5.32 Other salient features of meters

- It should be possible to check the healthiness of phase voltages by phase indicator available on meter display.

- The meter shall have provision of reading in the absence of power through an internal battery. It shall be possible to access the display in power off condition. It shall also be possible to do meter data download through MRI under power off condition.

- The meter should work accurately irrespective of phase sequence of the supply.

5.33 Test and test conditions

- Acceptance test: All acceptance tests as per relevant standards shall be carried out in the presence of utility representatives.

- Routine Test: All the routine tests as per – IS 14697 shall be carried out and routine tests certificates shall be submitted for approval of purchaser.

6 PACKING – TRANSPORT AND INSTALLATION

The Package Substation shall be delivered in a protective cover made of polythene or similar product. Lifting facilities for transportation of the complete unit shall be provided. Commissioning and operating instructions shall be provided with each substation.

7 TESTS

The type test report should have been carried out within 5 years from the date of opening of the tender. Following type tests shall be submitted:

1. Insulation level of the prefabrication substation.
2. Temperature rise test of the main components contained in a prefabricated substation.
3. Rated peak and the rated short time withstand current of earthing circuits.
4. Degree of protection for each compartment.
5. Mechanical withstand test of the enclosure.
6. Internal arc fault test of the USS with main component fitted inside enclosure.
7. Test to verify the sound level of the prefabricated substation

1 Applicable Standards : IEC: 60183, 60227, 60502, 60885
BS: 6500/IS 1554, 7098

2 Parameters

a) Rated voltage
- i. HV cables : 33 kV/ 11 kV
- ii. LV power and control cables : 1.1 kV
- iii. Lighting wires in conduits : 300/ 500 V

b) Installation:
- i. In air or buried in ground.
- ii. Depth of laying in ground for directly buried 33 kV cables 1050 mm and 11 kV 900 mm cables & 750 mm for LV cables
- iii. In conduit: space factor not more than 40 %.
- iv. In trays: single layer, touching.

c) Conductor Material : Aluminium for HV & LV power cables of greater than 10 mm^2. Copper for all control cables, DC cables, and lighting wires.

e) Insulation : XLPE (for HV/MV/LV, control cables and lighting wires)

f) Outer Sheath : Extruded FRLS (for Control cables)

g) Inner sheath : Extruded

h) Multi core cables : Control cables shall be as per the BOQ and site requirements. All CT cables shall be 4 sq. mm and PT cables shall be 2.5 sq.mm. Cables connecting to battery shall be single core types. Other DC supply cables shall be either 2C x 2.5 sq. cable or part of bigger size cables.

i) Armouring : Galvanised steel (Aluminium for single core)

3 MV/LV Cables

a) 33 kV cables - 33 kV, 4 C x 400 sq.mm XLPE, Aluminium, earthed grade cable. (As per the BOQ).

b) LV cables - 1.1 kV grade, 4C x 400 sq.mm,

XLPE, Aluminium, earthed grade cable, Rating as per BOQ and if the same is not adequate it shall be decided during detail engineering.

The above sizes are tentative and shall be decided during detail engineering.

4 The cable lengths indicated in price schedule shall be considered for evaluation. However, it is Contractor's responsibility to provide the cable schedule based on unit rates furnished during bidding. **The contractor is to procure the cables only after finalizing the cable schedule and not based on the BOQ in order to minimize the stores and spares.**

5 LT and DC cables shall be sized taking into consideration maximum voltage drop of 2%.

6 33 and 11 kV cables shall be supplied in steel drums. The contractor may take back the steel drum after completion of the works.

7 Tests

7.1 Cables shall be subjected to routine tests as per the applicable standards.

8 **Cable Trays and Carrier System**

8.1 Cable Trays supports

Cable tray supports such as angles, channel, etc shall be of MS type.

8.2 Cable Trays

8.2.1 For power cables, cable trays of MS ladder type shall be used. Accessories such as tees, elbows, reducer, etc. shall be fabricated out of minimum 2 mm thick sheet of hot dip galvanised type. Cable tray supports shall be at 1000 mm interval. If at the time of execution it is found that the cable trays sag, it is Contractor's responsibility to provide additional supports at no extra cost.

8.2.2 For Instrumentation and control cables, perforated type Aluminium cable trays of minimum 5 mm thick sheet of hot dip galvanised type shall be used. The outdoor cable trays if exposed to sun also shall be covered with the cover.

9 **Power and Control Cable Terminations**

9.1 Terminals for power connections shall be complete with adequate phase segregating insulating barriers, shrouds and suitable crimping type of lugs for terminating the cables.

9.2 Double compression type glands with armour and bonding clamps for the termination of all solid dielectric shall be provided. They shall be designed to secure the armour wires to provide electrical continuity between the armour and the threaded fixing component of the gland and to provide watertight seals between the cable outer sheath and gland and between the inner sheath and threaded fixing component. The gland shall preferably project above the gland plate to avoid entry of moisture.

9.3 Earthing connectors between cable armour and earth shall be routed outside the cable gland in an approved manner. Gland insulation shall be capable of withstanding test for appropriate high voltage for one minute.

9.4 Cable terminations and jointing for HV/LV cables shall be carried out with heat shrinkable type termination kits. Adequately sized shrouds/bolts shall be provided at connections to completely cover the terminations.

IV: Technical Specification of LT Distribution Panel, Distribution Pillars and Mini Distribution Pillars

1 Standards

The A.C distribution panel & pillars with their accessories shall confirm to the latest edition of the following standards as mentioned below (amended up to date) except where specified otherwise in this specification.

i.	IS: 8623	Specification for factory built assemblies of switch gear control gear for voltage upto and including 1000V AC and 1200V DC
ii.	IS: 4237	General requirements for switchgear and control gear for voltage not exceeding 1000V.
iii.	IS: 3147	Degree of protection provided by enclosures for low voltage switchgear and control gear.
iv.	IS: 2516	Air circuit breaker
v.	IS: 3156	Voltage Transformer
vi.	IS: 2705	Current Transformer
vii.	IS: 3231	Electrical relays
viii.	IS: 4064	Air Beak Switches
ix.	IS: 9224	Low Voltage fuses
x.	IS: 6875	Switch and push buttons
xi.	IS: 722	AC meters
xii.	IS: 6005	Code of Practice for phosphating of iron and steel
xiii.	IS: 1248	Measuring Instruments
xiv.	IS: 2633	Hot dip galvanizing
xv.	IS: 375	Marking arrangement of bus bars

2 Drawings

2.1 The bidder shall be required to furnish following and catalogues along with the bid

i. General arrangement drawing of AC Distribution panel
ii. Cal schematic diagram of AC distribution pillars.
iii. Technical and descriptive literature giving details of the equipment offered.

2.2 After receipt of the order, the successful bidder will be required to furnish six prints of the following drawing for approval.

i. Complete assembly drawings of AC distribution panel/pillars showing plan, elevation, sectional views and location of terminal blocks, cable entry details.
ii. Control and wiring diagram for each module of AC distribution panel/pillars including all spare terminals and inter modulars.
iii. Foundation plan showing location channels, nails, foundation bolts etc.
iv. Schematic Control diagram for control interlocks, relays, instruments and space heaters for each type of module.
v. Protective relay characteristics for each type of relay.
vi. Fuse characteristic curve for each type and rating.

3 General Requirements

3.1 LV Distribution panels and mini pillars shall be of metal clad, totally enclosed, indoor floor-mounted, free-standing cubicle type.

The distribution pillar should be designed for outdoor installation and have a short circuit rating of 35 KA for 3 second. It should be designed for termination of all cables from the front. Also operation of all fuse-switches and links should be from front only. It should have minimum 350 mm. clearance from lower most termination to the cable clamp. Each board shall be complete with terminal boards, interlocking gears, screens, guards and other necessary sundries whether specified or not. The cable entry shall be from the bottom.

The design/layout of the Distribution pillar/mini pillars should be compact/convenient and should provide ease of termination of cables and operation. The design/layout shall be subjected to approval of BPC.

3.2 All distribution panels, Distribution pillars & mini pillars frames shall be fabricated using suitable mild steel structural sections or pressed ad shaped and shaped cold-rolled sheet of thickness not less than 2.5 mm. frames shall be enclosed in cold-rolled sheet steel of thickness not less than 2.5 mm. doors and covers shall also be cold-rolled sheet steel of thickness not less than 2.5 mm. stiffeners shall be provided wherever necessary.

3.3 All panels edges and cover/door edges shall be reinforced against distortion by rolling bending or by the addition of welded reinforcement member.

3.4 The complete structures shall be rigid, self supporting, free from flaws, twists and bends. All cut-out shall be true in shape and devoid of sharp edges.

3.5 All LT Distribution panel for indoor use shall be of dust vermin proof construction and shall be provided with a degree of protection of IP-52 as per IS: 2147. However, the bus bar chamber having a degree of protection of IP-42 in accordance with IS: 2147 are also acceptable. Provision shall be made in all compartments for providing IP-52. Degree of protection when circuit breakers of module trolley has been removed. All cut-outs shall be provided with neoprene/synthesis rubber gaskets. However, all pillars for outdoor installation shall have IP-54 degree of protection (minimum).

3.6 Distribution panels shall be of a uniform height not exceeding 2300 mm.

3.7 Distribution panels shall be easily extendable on both sides, by the addition of the vertical sections after removing the end covers.

3.8 After isolation of power and control circuit connections, its shall be possible to safely carry out maintenance in a compartment with the bus bar and adjacent circuits live. Necessary shrouding arrangement shall be provided for this purpose over the cable terminations located in cable alley.

The minimum clearance in air between phases and between bus to earth for the entire run of horizon and vertical busbars shall be 25 mm. for all other components, the clearance between "two live parts", "A live part and earth part" and isolating distance shall be at least ten(10) mm throughout. Wherever it is not possible to maintain this clearance, insulation shall be provided by sleeving or barriers. However, for horizontal run of busbar minimum clearance of 25 mm should be maintained even if they are sleeved.

3.9 The temperature rise of horizontal and vertical busbars when carrying the rated current along its full run shall in no case exceed 55 degree C, with silver plated joints and 40 degree C with all other type of joints over an outside ambient temperature specified in section general.

3.10 Distribution panel/pillars shall be single front and shall be provided with openable covers at front and rear. The covers shall be provided with danger labels and locking arrangement.

3.11 All identical circuit breakers and module chassis of same size shall be fully interchangeable without having any carryout modifications.

3.12 All identical circuit breakers shall be fixed type except air circuit breaker modules.

3.13 All equipment and components shall be neatly arranged and shall be easily accessible for operation and maintenance. The internal layout of all modules shall be subjected to BPC approval.

3.14 LV Distribution pillar and mini pillars shall be attached at the base to frame with 4 legs of suitable size made from MS angle 60X60X6 mm. the height of legs (MS angle 60X60X6) shall be adjusted according to the site requirements and it shall be 600 mm above the ground level.

3.15 The LV distribution pillar shall be of type.

a) shall be with 400 Amps busbar without MCCBs/HRC fuse units with provision of cable termination for 6 nos.

4 Busbars and Isolators

4.1 All parts of the pillars including busbars, connections, isolators, fuses, contacts and terminals shall comply, with regard to rating, temperature rise and overload, with the appropriate requirements and shall be capable of operating continuously with injurious heating at full rated output. All conductors, connections and contacts shall be ample section and surface area for carrying the specificd short circuit current for the specified time to enable the supply fuse or circuit breaker clears the fault.

4.2 The AC Distribution panel/pillar shall be provided with three phase and a neutral copper bus bars.

4.3 All bus bars and jumper connections shall be of high conductivity copper of adequate size. The busbars shall be rated for 800 amps for distribution pillar and 400 amps for mini pillar for continuous.

4.4 The cross section of the bus bar shall be uniform and shall be adequately supported and braced to withstand the stresses due to the specified short circuit current.

All bus shall be adequately supported by non-hygroscopic, non-combustible, track-resistant and high strength type polyster fibre glass molded insulators. Separate supports shall be provided for each phase and neutral bus bars. If a common support is provided anti-tracking barriers shall be provided between the supports.

4.5 All bus bars joints shall be provided with high tensile steel bolts/spring washers and nuts, so as to ensure good contacts at the joints. Non-silver plated bus bar joints shall be thoroughly cleaned at joint locations and suitable contact grease shall be applied just before making a joint.

4.6 All bus bars shall be color coded as per IS: 375

4.7 The bidder shall furnish calculations along with the bid establishing the adequacy of bus bar sizes for specified current ratings.

5 Earth Bus

5.1 A copper earthing bus shall be provided at the bottom of each panel and shall extend throughout the length of each Distribution panel. It shall be welded/bolted to the frame work of each panel and breaker earthing contact point. Vertical earth bus shall be provided in each vertical section, which in turn is bolted/welded to main horizontal ground bus.

5.2 The earth bus shall have sufficient cross-section to carry the momentary short circuit and short circuit time fault current to earth without exceeding the allowable temperature rise.

5.3 Suitable arrangement shall be provided at each end of the horizontal earth bus for bolting to substation earthing conductors. The horizontal earth bus shall project outside the Distribution panel/pillar ends and shall have predrilled holes for this connection. All joints to earth bus shall be made through at least two bolts.

5.4 All non-current metalwork of the Distribution panel/pillar shall be effectively bounded to the earth bus. Electrical conductivity to the whole switch gear enclosures frames work and the truck shall be maintained even after painting.

5.5 The truck and their circuit breaker frame shall get earthed while the truck is being inserted in the panel and positive earthing of truck and breaker frame shall be maintained in all positions i.e. “service” & “isolated” as well as throughout the intermediate level.

5.6 All the metallic cases of relays, instruments and other panel mounted equipment's shall be connected to earth bus by independent standard copper wires of size not less than 2.5 sq.mm. Insulation color code of earthing wires shall be green. Earthing wires shall be connected to terminals with suitable clamp connectors. Soldering is not acceptable. Looping of earth connection which would result in loss of earth connection to other devices when a device is removed is not acceptable. However, looping of earth connections between equipment to provide alternative paths or earth bus is acceptable. VT and CT secondary neutral paint earthing shall be at one place only on the terminal block. Such earthing shall be made links so that earthing of one secondary circuit shall be removed without disturbing the earthing of other circuit.

5.7 All hinged doors shall be earthed through flexible earthing braid.

5.8 Caution nameplate "Caution – Live Terminals" shall be provided at all points where the terminals are likely to remain live and isolation is possible only at remote end.

6 Instruments

6.1 Indicating and integrating meters shall be flush mounted on panel front. The instruments shall be of at least of 96 mm square size with 90 degree scales, and shall have an accuracy class of 1.5 or better. The covers and cases of instruments and meters shall provide a dust and vermin proof construction.

6.2 All instruments shall be compensated for temperature errors and factory calibrated to directly read the primary quantities.

6.3 All instruments shall have white dials with black numerals and lettering. Black knife-edge pointer with parallax free dials will be preferred.

6.4 The following indicating instruments shall be provided in LV Distribution pillar 1 No. Ammeter & 1No. Voltmeter with selector switches to read all three phases.

7 Push Buttons

7.1 Push-buttons shall be of spring return, push to actuate type. Their contacts shall be rated to make, continuously carry and break 10 A at 240 AC.

7.2 All push-buttons shall have one normally open and one normally closed contact, unless specified otherwise. The contact faces shall be of silver or silver alloy.

7.3 All push-buttons shall be provided with integral escutcheon plates marked with its functions.

7.4 The color of the button shall be as follows:

Red:	Breaker Close
Green:	Breaker Open

Black:	For overload reset

8 Indicating Lamps

8.1 Indicating lamps shall be of the panel mounting filament type and low watt consumption. Lamps shall be provided with series resistors, preferably built-in the lamps assembly. The lamps shall have escutcheon plates marked with its function, wherever necessary.

8.2 Bulb and lamp covers shall be easily replaceable from the front of the cubicle.

9 name Plate and Labels

9.1 All switchgears, Distribution pillars shall be provided with prominent, engraved identification plates. The module identification plate shall clearly give the feeder number and the feeder designation. For single front switchboards, similar panel and board identification labels shall provided at the near side.

9.2 All name plates shall be of non-rusting metal or 3-ply lamcoid with white engraved lettering on black back-ground. Inscriptions and lettering sizes shall be subjected to BPC.

9.3 Suitable plastic sticker labels shall be provided for easy identification of all equipment, located inside the panel/module. These labels shall be positioned so as to be clearly visible and shall give the device number, as mentioned in the module wiring drawings.

10 Space Heater

10.1 Space heater shall be provided in the Distribution pillar for preventing harmful moisture condensation. The space heaters shall be suitable for continuous operation at 240 V AC, 50 Hz. Single phase supply and shall be automatically controlled by thermostats. Necessary isolation switches and MCB's shall be provided.

11 Tests

11.1 AC Distribution panel/pillars, circuit breakers, instrument transformers, relays, meters etc., shall comply with the type test requirements and subjected to routine tests as per the relevant standards.

11.2 Type test reports for circuit breakers, bus bars, instrument transformer, relays and other important components shall be furnished by the successful bidder before the fabrication of Distribution panel/pillars is started.

11.3 Routine test shall be carried out on all Distribution panel/pillars and associated equipment's as per relevant IS by the manufacturer and witnessed by BPC.

11.4 Routine test shall be carried out ion the presence of the Purchaser's representative if so desired by the purchaser.

11.5 All type reports according to IS: 8623 shall be submitted before dispatch of the equipment Routine Test reports should be approved from the Purchasers before dispatch of the equipment.

11.6 Equipment shall only be dispatched after the test certificate have been approved by BPC or its representative and written dispatch instructions issued to the equipment supplier/manufacturer.

12 Completeness of Equipment

The above details are representative technical details. The supplier/manufacturer of equipment shall ensure the completeness of equipment and any other item not specifically mentioned but required for the successful operation of the equipment or the safety of personal or to comply with the Indian Standard specifications shall be deemed to be include in the scope of supply without any financial liability to BPC, during the approval of drawings.

Lighting System

1 Applicable Standards: IEC 60083, 60598, 60669, 60884, 60906 and 60947/IS1913

2 General Requirements

2.1 Lighting system equipment shall cover lighting panel, lighting fixtures, switches, receptacles with switches, outdoor lighting inclusive of outdoor lighting masts, street lighting poles, etc.

2.2 Normal and emergency lighting for indoor and outdoor areas shall be provided. Separate lighting panels shall be provided for indoor and outdoor areas.

2.3 Emergency supply shall be derived from 110V DC distribution board to be provided under this contract. Or a separate inverter shall be provided for emergency lighting.

2.4 Each lighting panel shall have facility for feeding the circuits, which would operate on emergency supply.

3 Lighting Panels

3.1 Lighting panels shall be of wall/floor mounting type and fabricated out of 1.6 mm thick cold rolled sheet steel. Incomer circuit shall be controlled by a load break type, triple pole switch or an MCB with a link in the neutral circuit. Outgoing circuits shall be controlled by single pole MCBs of minimum 6A for light points and 16 A for power points. Breaking capacity of MCBs shall not be less than 10 kA. Residual current circuit breakers shall be provided on all lighting and receptacle circuits.

3.2 The incomer circuit shall have bottom cable entry. It shall be possible to take out outgoing circuits from top and bottom. Knockout for cable/conduit entries for all the outgoing circuits shall be provided. Separate circuit for control of lighting fixtures and receptacle shall be provided. Each phase shall have at-least one spare circuit.

3.3 The panel shall be provided with 3 phase and neutral copper busbar adequately rated to cater to the requirement of all the outgoing circuits. Two earthing terminals shall be provided external to the panels for terminating the external earthing conductor.

3.4 The panel shall be internally wired using colour coded, stranded copper conductor, PVC insulated wires of 1100 V grade 2 nos. voltage relays suitable for connection on 240 V, 1 phase power supply and one contactor suitable for operation on 110 V DC shall be incorporated for sensing failure of AC supply and energizing emergency lighting circuit.

3.4 Day timers shall be provided for automatic switching off outdoor lighting.

3.5 The panels shall have hinged door, gasketed all round and provided with handle lock. Operation of incomer switch or MCBs shall be possible without opening the door.

4 Lighting fixtures and its accessories

4.1 Lighting fixtures for illumination of outdoor and indoor area shal1 be supplied. Fixtures for outdoor/semi-outdoor installation shall be of weatherproof design with degree of protection of at least IP67.

4.2 Fixtures shall be complete with internal wiring, lamp, power factor correcting capacitors, starter, holder, ballast, reflector, louvres/perspex, etc. as required for their satisfactory operation.

4.3 Following types of fixtures shall be considered for various areas:

a) General purpose flood lighting fixtures - Housing from die-cast aluminium alloy, vitreous enameled, and with electrochemically brightened anodized aluminium reflector, a clear heat resistant glass, with rubber gasket, secured to housing by aluminium ring, cast iron base and MS cradle for turning in horizontal and vertical planes and lockable in desired position, suitable for 80 W LED lamp with control gear. These fixtures shall be used for illumination of outdoor substation equipment and for providing general illumination. These fixtures shall have asymmetrical light distribution and shall be mounted on gantry structures.

b) Gate post lights - Top canopy spun from aluminium sheet and vitreous enameled. Aluminium fins shall be fixed on the canopy at top and spigot at bottom. Spigot shal1 be made of die-cast aluminium and vitreous enameled. Fixture shall be suitable for 45 W LED lamp.

c) Decorative type LED fixtures - Housing made from mild steel sheet and stove enameled white. Reflector assembly made from electrochemically brightened anodized aluminium sheets secured to housing with spring loaded triggers and suitable for 2 nos. 36 watt. These fixtures shall be used in switchgear room and other areas where false ceiling is provided. Fixtures shall be suitable for recessed mounting in false ceiling.

d) Decorative type LED fixtures of the enclosed type - Tube mounting channel made from mild steel sheet and stove enamelled white. Diffusers made from opal acrylic sheet and suitable for 1 or 2 nos. 36 W. These fixtures shall be provided in areas without false ceiling and suitable for surface mounting.

e) Corrosion resistant type lighting fixtures suitable for 2 nos. 36-watt LED shall be provided in battery room.

f) Well glass type fixtures - Housing made from die-cast aluminium alloy, vitreous enamelled, grey hammer tone outside and white inside. A clear screw type neck fixed on housing and sealed with gasket. Fixture

provided with mild steel zinc coated wire guard and suitable for 50 W LED lamp. These fixtures shall be used on emergency circuit and located near each main transformer marshalling box.

g) Decorative fixtures with glass/perspex covers suitable for emergency lighting in control room and battery room. Fixtures shall be suitable for recessed mounting in false ceiling wherever the latter is provided.

h) Street lighting fixtures for the approach road shall be weatherproof, suitable for 80 W LED lamp and shall be cut-off type. The fixtures shall be of die-cast aluminium with electrochemically brightened anodised aluminium reflector and with transparent polycarbonate cover.

i) Types of fixtures proposed by the Contractor for various areas shall be subject to Engineer's approval.

4.4 The capacitor in the lighting fixture shall have adequate value of capacitance to correct the power factor to 0.95 lag.

4.5 Each fixture shall be complete with a four way terminal block for connection and looping of incoming and outgoing cables. Each terminal shall be able to accept two 2.5 sq. mm stranded copper conductors.

4.6 Each lighting fixture shall be provided with an earthing terminal suitable for connecting 16 SWG stranded copper conductor.

5 Illumination levels

5.1 Lighting system shall be installed to achieve the average maintained levels of illumination as indicated below. The Contractor shall be required to measure the actual levels and carry out necessary modifications to accomplish specified levels. It is to be noted that the values measured after installation will exceed those specified by a factor that is equal or greater than the reciprocal of maintenance factor. Measurement shall be carried out after 100 burning hours.

a)	Control room, Switch gear room, etc.:		400 lux
b)	Passage, toilet, battery room, store, etc.	:	150 lux
c)	Outdoor substation equipment and outdoor areas	:	30 lux
d)	Internal Roads	:	20 lux

5.2 The illumination system shall be so that the uniformity factor is of acceptable level and that the glare is within limits. The ratio of maximum to minimum illumination levels shall not exceed 20 in outdoor area within the fence.

5.3 The following values of maintenance factors shall be considered for design:

a) Outdoor area : 0.6

b) Indoor air-conditioned area : 0.8

c) Other indoor areas : 0.7

5.4 The Contractor shall furnish detailed design calculations along with a contour map of illumination levels for outdoor area and control room, uniformity factors, ratio of maximum to minimum illumination levels, ratio of average to minimum illumination levels, glare indices, etc. for approval. Detailed characteristics of various types of fixtures including but not limited to, illumination curves and tables shall also be furnished for review during detail engineering.

6 Receptacles with switches

6.1 Receptacles of 5A and 15A rating with switches suitable for operation on 240 V AC, 1 phase, 50 Hz supply shall be provided as detailed below:

a) Decorative and industria1 type shall be proposed in relevant areas.

b) Receptacles proposed for outdoor/semi-outdoor installation shall be of weatherproof design with degree of protection IP 67.

c) Receptacle shall be housed in galvanised steel boxes.

6.2 Fo1lowing quantities of receptacles shall be considered

a) Control room cum switchgear room :
2 nos. 5A and 3 nos. 15A industrial type.

b) Near each transformer:
1 no. each 15A industrial, weather-proof type

7 Switches

7.1 Decorative/ industrial type switches of 5A/10A rating shall be provided for all indoor areas. Switches shall be provided to control a group of lighting fixtures in various areas. Switches shall be housed in galvanized steel boxes.

7.2 Scope of Lighting system for various areas:

a) Indoor lighting system for the respective rooms and outdoor flood lighting for roads, transformer and entrance.

8 Tests

8.1 Lighting panels, fixtures, receptacles and other accessories shall be subjected to routine and acceptance tests as per the applicable standards.

6.2 **Earthing Protection System**

6.2.1 Applicable Standards : ANSI/IEEE Std. 80 & 142
IEC 61024, IS:2303,
IS:3043, IS:2309

6.2.2 Requirements

6.2.2.1 Following material and sizes of earthing conductors, electrodes and shield wire shall be used for various purposes:

a) Main earthing grid (buried in ground) - 50 x 6 mm MS

b) Earthing leads for outdoor substation equipment - 50 x 6 mm MS (below ground) and 50 x 6 mm GS (above ground)

c) Earth electrode - 40 mm dia, 3000 mm long, heavy gauge MS/GI pipe

d) Distribution boards, control and relay panels, lighting panels, battery chargers, etc. - 25 x 3 mm GS

e) Lightning shield wire - 7/3.35 mm stranded GS wire

f) 16 SWG copper wire for lighting fixtures, metallic conduits, switch/receptacle boxes, etc.

6.3 33/ 11 kV Structure

6.3.1 33 and 11 kV Incoming and outgoings from the 33/11 kV switchgear shall be by 11 kV grade earthed cables. The cables shall be terminated on a take-off structure.

6.4 Insulators and Hardware

6.4.1 Applicable Standards : IEC 120, IEC 305, IEC 372, IEC 383, IEC 575, IEC 1109, ANSI C29.6, and ANSI C29.4

6.4.2 Pin Insulators

a) Pin insulators shall be manufactured to IEC 383.1 and ANSI C29.6, Class 56.2 and Class 56.4. The insulators shall have necks suitable for fastening conductors with tie wire or preformed fitting. Conductor sizes up to 200 mm^2 ACSR will be used.

b) Pin insulator shall have the following minimum characteristics.

Characteristics	Unit	**33 kV**	**11 kV**
Designation (ANSI C29.6)		Class 56.2	Class 56.2
Cantilever strength	kN	10.7	10.7
Nominal diameter	mm	305	229
Nominal height	mm	241	165
Nominal creepage distance	mm	686	432
Puncture voltage	kV	185	145
Minimum power frequency flashover voltage dry wet	kV kV	140 95	110 70

c) Each pin insulator shall be supplied complete with a hot dip galvanised forged steel pin, complete with nut, lock nut and spring washer. The ultimate mechanical strength of the pin insulator assembly shall be equal to the above cantilever strength. Pin insulators shall be supplied with pins to fit on crossarms.

6.4.3 String Insulators

a) The string (tension disc) insulators shall be the ball and socket type conforming to IEC 305 and IEC 120.

b) Each disc of the string insulators shall have the following minimum characteristics.

Characteristics	Unit	
Designation (IEC 305)		U 80 BL
Mechanical failing load	kN	70
Nominal diameter	mm	255
Nominal spacing	mm	145
Nominal creepage distance	mm	280
Puncture voltage	kV	145
Minimum power frequency flashover voltage Dry	kV	78
Wet	kV	45

c) Each string assembly shall consist of one (for 11 kV) or three (3 nos. for 33 kV) tension disc insulators, ball and socket couplings (16 mm to IEC 120), and a deadend clevis thimble suitable for preformed terminations of 150 mm^2 or 100 mm^2 or 50 mm^2, ACSR conductors.

d) String insulator assemblies shall be supplied each complete with crossarm straps, clamp ball, insulator(s), deadend clevis thimble, necessary GI bolts, nuts, flat and spring washers to fit on crossarms.

6.4.4 Miscellaneous Clamps/Connectors/Lugs

a) Miscellaneous clamps/connectors and lugs shall be to suit above sizes of earthing rod/pipe/conductor. Clamps and connectors shall have bolted connections with 2 nos. bolts.

b) Suitable bimetallic clamps shall be provided for connecting 1Cx6 sq. mm copper conductor to GI spike earthing rod.

6.6 Tests

6.6.1 Certificates of type tests carried out on arresters, insulators and hardware of similar type shall be furnished during detail engineering.

6.6.2 Routine tests and acceptance tests as per the applicable standards shall be carried out on the arrester, insulators and hardware in the presence of Employer's representative.

6.7 Ventilation System

Suitable ventilation system shall be provided for switchgear room as required. The ventilation system shall consist of propeller exhaust fans with weather proof louver. Minimum 15 changes/hour shall be considered for ventilation of each room.

6.8 Fire Fighting System

Portable fire extinguishers of CO2 (3-kg capacity), bearing ISI/UL/other international standards marking shall be installed in the substation building. Sand buckets properly painted with red colour and associated mounting structure shall be provided near the entrances and 2.5MVA transformer.

6.9 Rubber Mats

1 m (l) x 0.75 m (w) x 0.003 m (t) rubber mat of black colour shall be installed in front of each ACDB, DCDB and 33 kV and 11 kV switchgear.

Section 2C – Technical Specifications (Civil)

2C – TECHNICAL SPECIFICATION (CIVIL)

1.0 General

1.1 This specification covers the general requirements with supply of all materials and construction of civil related works and fabrication of structural steel works.

1.2 The contractor shall perform the works to meet the requirements of this specification, the attached bid drawings and the relevant articles of this Contract Document.

2.0 Standards & Applicable Codes

2.1 All materials, design, fabrication, galvanising and tests under these specifications shall conform to the latest applicable Indian Standards, codes or their equivalent established and approved in the country of manufacturer, and approved as equal by Engineer.

2.2 Any details not specifically covered by these standards and specifications shall be subjected to approval by Engineer. In the event of contradictory requirements between the standards and the specifications requirements, the terms of the specifications shall apply.

2.3 The Contractor may propose equivalent standards, specifications, materials etc. which shall be equal in every aspect as specified. If the Contractor for any reason proposes equivalents to or deviations from the above standards, he shall state the exact nature of the change or the reason for making the change and shall submit complete specifications of the materials as well as copies of pertinent standards for the approval of Engineer and decision of Engineer in the matter of acceptability will be the final.

3.0 Materials

All materials shall be as per the specifications and shall be approved by the Engineer before use in the works. Samples of materials, fittings etc. shall be submitted by the contractor for approval of the Engineer before bulk supplies are brought on the site of works. The samples so approved shall be kept in the custody of Engineer till the completion of works. When required by the Engineer, the contractor shall supply for the purpose of testing, samples of any materials proposed to be used in the works.

4.0 Testing of materials

Samples whether submitted to govern bulk supplies or required for testing before use shall be tested and the testing charges, if any, shall be borne by the contractor. Testing of materials like concrete, brick, sand, aggregates, reinforcement and any other civil materials may be done as and when instructed by the engineer. Any materials failing from the test will be not allowed to use at site

5.0 Safety on works

Safety precautions pertaining to construction works such as excavation trenching, blasting, demolition, provision of scaffolds, ladder, working platforms, gang ways, mixing of asphalt materials, electric arc and gas welding, use of hoisting and construction machinery shall be taken care by the contractor.

6.0 Antiquities and useful materials

Any finds at the time of excavation such as relics of antiquity, coins, fossils or other articles of value shall be delivered by the contractor to the Engineer and shall be the property of the Government. Any materials obtained from the excavation which in the opinion of the engineer is useful, shall be stacked separately in regular stacks as directed by the engineer and shall be the property of the Government.

7.0 Bench marks

Temporary site bench mark shall be constructed at the construction site, where so required by the Engineer.

8.0 Quality of Materials and Workmanship

The materials and workmanship shall be of the best of their respective kinds and shall be to the approval of the Employer or his representative on Site, the Engineer.

The contractor shall carry out modifications in the procedure of work, if found necessary, as directed by the Engineer during inspection. Substandard quality of work shall be rectified/redone at the contractor's own cost, and defective work/material shall also be removed from the site of works by the contractor at his own cost.

The Engineer may ask to carry out the field/Laboratory tests mentioned in the specification and the cost of carrying out such tests which include equipment charges, tools, materials, labour and incidentals to perform tests and other operations of quality control according to the specification requirements shall be deemed to be incidental to the work and no extra payment shall be made for the same. Sampling and testing procedure to be used shall be as approved by the Engineer and his decision shall be final and binding on the contractor.

9.0 Equivalency of Standards and Codes

Wherever reference is made in the Contract to specific standards and codes to be met by the goods and materials to be furnished and work performed or tested, the provisions of the latest current edition or revision of the relevant standards and codes in effect shall apply, unless otherwise expressly stated in the Contract. In case of any differences between the standards specified and the proposed alternative standards shall be fully described in writing by the Contractor and submitted to the Engineer at least 28 days prior to the date when the Contractor desires the Engineer's consent. In the event of the

Engineer determines that such proposed deviations do not ensure substantially equal or higher quality, the Contractor shall comply with the standards specified in the documents.

No materials of any description shall be used without prior approval by the Engineer and any condemned as unfit for use in the works, shall be removed immediately from the site by, and without recommendation to, the Contractor.

If these specifications do not cover these items then the relevant IS codes shall be applicable. Where no reference is found in the above specifications for an item of work then sound engineering practice as decided by the Engineer shall be applicable and the decision of the Engineer in respect to all such matters relating to specifications shall be final and binding on the contractor.

10.0 Signboards

The Contractor shall erect signboards in prominent positions adjacent to the works to the satisfaction of the Engineer/in line with the requirement of CDB.

11.0 Environmental Management Plan

The Contractor's shall submit an Environmental Management Plan, where the Contractor explains how the site shall be organized, how the contractor shall proceed with the works, and how the activities shall be executed to comply fully with the rules explained in the Bhutanese Environmental Codes of Practice.

12.0 Location of Camp

The contractor shall locate the Contractor Camp away from settlements, drinking water supply intakes, landslides or flood prone areas. This will help to avoid social conflicts and the pollution of such sites and unsanitary waste disposal.

13.0 Scope of Works

The scope of works for civil works, architectural, structural and foundations shall include preparation of ground, supply of all materials to site including insurance and storage, provision of all labor, qualified supervisory personnel, instruments, tools, erection of plant and equipment, fixtures, fittings and all temporary and permanent works necessary, whether or not such items are specifically stated herein for satisfactory completion of the job in all respects in accordance with the specification or as mentioned in the BoQ.

14.0 Grading & Leveling of Area

Site be graded to the required level by cutting & filling. In case of filling, the excess depth be brought to the required level by using cement concrete of M-10 Grade. Area shall also be cleared of Jungle, bushes, vegetation, trees including its roots etc. and stacking of serviceable materials and disposal of other material as directed by engineer. Filling in the excavated areas shall be done with sand.

15.0 Excavation

15.1 Earthwork in excavation for various foundations can be carried in all types of soil including soft/fissured/hard rock. The work shall also include dewatering in case confronted in any area. The scope of work also covers disposal of surplus excavated material after filling back of foundation.

15.2 Excavation shall conform to the dimensions and elevations as shown on the approved drawings. When foundations rest on an excavated surface other than rock, special care shall be taken not to disturb the bottom of excavation. When subsoil for foundation becomes murky on top due to construction operation or any other reason, such subsoil shall be removed and replaced by one or more layers of compacted send or crushed rock as directed by Engineer.

15.3 If any drainage system exists in the vicinity of excavation, Contractor shall control the grading in the vicinity of all excavations so that the surface of the ground will be properly sloped to prevent surface water from running into the excavated areas during construction.

15.4 When machines are used for excavation, the last 300 mm before reaching the required level shall be excavated by hand or by such equipment that shall leave the soil at the required final level in its natural condition.

15.5 When excavation requires shoring, bracing etc. contractor shall submit to engineer drawing g showing arrangement and details of proposed installations and shall proceed only after getting approval from Engineer.

15.6 Excavated material suitable for use as backfill shall be deposited by contractor in storage piles at the area approved by Engineer. However, surplus and/or unsuitable excavated materials shall be hauled and transported to the disposal area designated by Engineer.

16.0 Backfill

16.1 Contractor shall place and compact the backfill materials to the lines, grade and dimension shown on approved drawings.

16.2 Prior to backfilling, all forms, temporary shoring, timber etc. shall be removed and clean all trash, debris, perishable/organic materials and shall be approved by engineer. The material to be used for backfill, the amount thereof and the manner of depositing the materials shall be approved by Engineer.

17.0 Cement

It shall be of approved brand. Cement shall be stored and stacked in bags in dry and water proof sheds. Cement bags shall not be stacked more than 10 bags high to avoid lumping under pressure. When removing cement bags for use apply the "first in, first out", rule, that is, take the oldest cement out first. Each consignment of cement shall be stacked separately therein to permit easy access for inspection and facilitate removal. Storage of cement at the site of

work shall be at contractor's expense and risk. In the event of any damage occurring to cement due to faulty storage in contractor's sheds or on account of negligence on his part such damages shall be the liability of the contractor.

18.0 Plain Cement Concrete (PCC)

100 mm thick M-10 grade be provided underneath the structural concrete/masonry as mud-mat. Concrete shall be always mixed by mechanical mixer unless otherwise the Engineer permits hand mixing.

19.0 Reinforced Cement Concrete (RCC)

All RCC shall be of M-20 grade concrete as per approved design and drawings. Concrete shall be always mixed by mechanical mixer unless otherwise the Engineer permits hand mixing.

20.0 Damp Proof Course (DPC)

DPC shall be M-15 grade of minimum thickness 50 mm with water proofing compound in ratio as recommended by manufacturer and thereafter applying a Hot Coat of bitumen.

21.0 Stone Masonry Work

All stones shall be wetted before use. Masonry shall be laid truly in plumb or to required batter where so specified. Height of construction in a day shall not exceed 1m so as to avoid excess load on fresh mortar.

22.0 Plaster

The joints shall be raked out properly. Dust and loose mortar shall be brushed out. Efflorescence if any shall be removed by brushing and scraping. The surface shall then be thoroughly washed with water, cleaned and kept wet before plastering is commenced. In case of concrete surface, if a chemical retarder has been applied to the formwork, the surface shall be roughened by wire brushing and all the resulting dust and loose particles cleaned off and care shall be taken that none of the retarder is left on the surface. The joints of masonry shall be raked out properly so that the plaster is well keyed with the masonry.

23.0 Water

Water used for mixing mortars and concrete shall be clean and reasonably free from injurious quantities of deleterious such as oil, acids, alkalis, salts and vegetable growth. Generally portable/drinkable water shall be used. Water found satisfactory for mixing is suitable for curing concrete. However, the water used for curing should not produce any objectionable stain or deposit on the concrete surface.

24.0 Stone boulder

Stone shall be hard, sound, free from decay, weathering and defects like cavities, cracks flaws, sand holes, veins patches of soft or loose materials etc. It shall be obtained from an approved quarry. Where required by the Engineer the stone shall be got tested for water absorption determined as per IS: 1124, the stone boulders shall not have round surfaces. The stone using for RRM works should be in blocks of size 150 x 150 x 900 mm unless directed otherwise by Engineer or stated.

25.0 Stone aggregates

These shall be crushed or broken from hard stones. It shall be hard, strong, dense and durable, clean and free from soft, friable, thin, flat, elongated or laminated, flaky pieces and shall be roughly cubical in shape. While stock piling, the aggregates shall not form pyramids resulting in segregation of different sized materials and height shall not exceed 1.5 m. The tests must be carried out for the stone aggregates to check their conformance to the requirements of the specifications.

26.0 Gravel or shingle

Gravel/Shingle can be from the river beds or pits. It shall be sound, hard, clean, suitably graded in size as specified without broken fragments. It shall be free from flat particles of shale, powdered clay, silt, loam and other impurities. However, pit gravel shall have to be washed.

27.0 Sand

Not more than 10% shall be retained on 4.75 mm IS Sieve. The sum of the percentage of all deleterious materials shall not exceed 5%. It shall not contain harmful organic impurities in any form or quantities which will adversely affect the strength and durability of concrete or mortar. It shall not contain any acidic material, which is likely to attack steel reinforcement. The tests must be carried out for the fine aggregates to check their conformance to the requirements of the specifications. The fineness modulus of sand to be used in plaster shall be between 1.0 and 1.5. The fineness modulus of sand to be used in concrete and for mortar required for masonry shall be between 2.0 and 3.1. The maximum quantity of silt shall not exceed 8%. Quantity passing through 150 microns IS Sieve shall not be more than 10%.

28.0 Bricks

The bricks shall be hand or machine moulded. They shall be free from cracks and flaws and nodules of free lime. The tests must be carried out for the brick to check their conformance to the requirements of the specifications.

Bricks required for brick work in cement mortar shall be adequately soaked in stacks, before use, by profusely spraying with clean water at regular intervals for a period of not less than six hours so as to keep them wet to the satisfaction of the Engineer. Bricks required for masonry with mud mortar need not be soaked.

Brickwork shall be laid in English bond unless otherwise specified. Half or cut bricks shall not be used except where necessary to complete the bond. Closures, in such cases, shall be cut to the required size and used near the ends of the walls.

In exposed brickwork, selected bricks shall be used for the face work.

29.0 Water Proofing Compound

It shall be of approved brand. The material shall not contain any harmful constituents, which are likely to impair the strength of cement. It shall conform to the specification of IS 2645.

30.0 Concrete Admixtures

These shall conform to IS: 9103. Admixture is a material other than water, aggregate, and hydraulic cement and additives like pozzolana or slag and fibre reinforcement used as an ingredient of concrete or mortar and added to the batch immediately before or during its mixing to modify one or more of the properties of concrete in the plastic or hardened state. The different types of admixture are as follows:

a) Accelerating admixtures,
b) Retarding admixtures
c) Water-reducing admixtures
d) Air entraining admixtures, and
e) Superplasticizing admixtures.

The chloride content in the admixture shall be declared by the manufacturer. Super plasticizers are expected to be chloride free. Admixtures that contain relatively large amounts of chloride may accelerate corrosion of prestressing steel. Where corrosion of such steel is of major concern, compliance with requirement of the specification of IS 9103 does not constitute assurance of acceptability of the admixture for use in prestressed concrete. In case of reinforced concrete, to minimize the chances of deterioration of concrete, the total chloride content in the concrete should be limited as specified in IS 456: 2000.

31.0 Final cleaning

Protective coating and warnings shall remain undisturbed until final acceptance, immediately prior to final inspection, temporary protection covering or coating shall be removed and surfaces shall be washed with a suitable thinner and left in a finished condition having approved uniform appearance and free from all marks and blemishes. Wash and polish glass on both faxes.

32.0 MS Angle, Tee, Channels, Flats/Plates/ Anchor Plates

All finished steel shall be well and cleanly rolled to the dimensions and weight specified subject to permissible tolerances as per IS 1852. The finished material shall be reasonably free from cracks, surface flaws, laminations,

rough and imperfect edges, and all other harmful defects. Steel sections, shall be free from excessive rust, scaling and pitting and shall be well protected. The decision of the Engineer regarding acceptability of the any steel section shall be final and binding on the contractor. The mechanical and chemical properties of the structural steel shall be as per Tables 3.6 and 3.7 respectively. The following varieties of steel shall be used for structural purposes: -

a) S.T. 42-S: - The standard quality steel designated as S.T.42-S, conforming to IS: 226 shall be used for all the types of structure (riveted or bolted) including these subject to dynamic loading and where fatigue, wide fluctuation of stresses, reversal of stresses and great restraint are involved as for example crane gantry girders, road and rail bridges etc. It is also suitable for welded structures provided that the thickness of materials does not exceed 20 mm.

b) S.T.42-W: - The fusion welding quality steel designated as S.T. 42-W, conforming to IS: 2062; shall be used for structures subject to dynamic loading (Wind load is not to be considered as dynamic for this purpose) where welding employed for fabrication and where fatigue, wide fluctuation of stress, reversal and great restraint are involved as for example, crane gantry girders and road bridges.

c) S.T.42-O: - The ordinary quality steel designated as S.T. 42-O, conforming to IS: 1977 shall be used for structures not subjected to dynamic loading other than wind loads where welding is not employed or/and structures not situated in earthquake zones or/and design has not been based on plastic theory.

d) S.T.32-O: - The ordinary quality steel designated as S.T.32- O, conforming to IS: 1977 shall be used for doors, windows bars, grills, steel gates, hand railing, builders hardware, fencing post, tie bars etc.

33.0 Other Requirements

The design details of foundations for the structures to be constructed by the contractor shall be subjected to approval by Engineer.

Foundation construction works includes excavation in all types of soil and backfill, shoring and pumping out water if required, conducting required tests, necessary embedment, curing and everything required for the satisfactory completion of works.

34.0 Concrete Works

Water, Cement, fine aggregate and coarse aggregate shall conform to material specifications. Concrete can be specified by proportions or by nominating the required strength.

Concrete shall be prepared by mixing graded stone aggregate or gravel of normal size as specified with fine aggregate and cement in specified proportions with required quantity of water.

35.0 Yard Fencing

This shall be as per the approved drawings.

36.0 Bar Bending Schedules

Before cutting and laying of the reinforcement for any RCC work, contractor need to submit the bar bending schedules and get the approval from the Engineer in charge. This shall be checked by the engineer at the site before implementing.

37.0 Daily Work/Monthly targeted Work Plan

Daily work plan need to be maintained at the site in proper register. The work plan for next day need to be discussed in the evening and need to follow as recorded.

Contractor need to submit the monthly targeted work plan to the Project Office for the proper monitoring purposes.

38.0 Miscellaneous

i) The specification for the works which is not covered above shall be carried out as per the specifications in the BSR and CPWD manual.

ii) The contractor and engineer shall carryout the joint measurements for all the works executed by recording every 15 days and certified to have executed as per drawing, design and specifications prior to release of on-account payments. Measurement shall be done as per actual and the unit will be as mentioned in the BoQ recording to two places of decimal.

iii) Provisional quantities are those quantities which may be executed as per site requirements.

39.0 Dimension of Equipments

Contractors shall provide all dimensions of equipments and Engineer's approval shall be shown on the approved design drawings and shall conform to the requirements described hereafter.

"*No changes shall be made without the written approval of Engineer*"

40.0 Steel Structure

40.1 General Requirements

The scope covers detail design, preparation of design drawings, fabrication drawing, fabrication, galvanising and erection of structural steel works wherever necessary. All designs and drawings shall be subjected to approval of engineer. Engineer shall have the right to instruct contractor to make any changes in design and details necessary to make the construction conform to the Contract Documents.

40.2 Materials

Steel shall conform to IS: 226/IS: 2062 (tested quality) for mild steel and IS: 961 for high tensile steel.

All connection bolts, U-bolts and nuts shall conform to IS; 6639. All washers (spring washers, bevelled washers, flat washers etc.) shall conform to IS: 2016/IS: 3063.

The minimum diameter of bolts shall be 16 mm. for members carrying calculated stress and minimum 12 mm. for other members.

Section 2D – Installation, Testing and Commissioning

SCHEDULE 2D - INSTALLATION

1.0 GENERAL

1.1 The scope shall cover complete installation of plant items and accessories as indicated in various parts of the specification. Requirements/ guidelines/ information/ parameters/ instructions etc. specified in this part shall apply to all the parts.

1.2 Installation work pertaining to plant items and systems such as cabling, lighting, earthing and lightning protection systems, etc. shall comply with the applicable standards, safety codes etc.

1.3 Installation shall be carried out strictly in accordance with the approved drawings. Changes, modifications, if any, required to suit site conditions, shall be carried out only with the prior approval of the Engineer. All such changes shall be incorporated in the "As built" drawings to be furnished by the Contractor.

1.4 All tools, welding equipment, crane, scaffolding, rigging materials, ladders, consumables, hardware etc. required for installation shall be provided by the Contractor.

1.5 It shall be the responsibility of the Contractor to engage specialist engineers from his Sub-contractors/Manufacturers to supervise installation work for sub-station items such as transformers, switchgear and other substation equipment where felt essential. Such services shall be arranged by the Contractor at no extra cost to the Employer.

1.6 It shall be the responsibility of the Contractor to obtain approval/clearance, if any, from local statutory authorities, for conducting any work for completed installation.

1.7 The Contractor shall ensure that all substations under erection as well as the work area and the project site are kept clean to the satisfaction of the Engineer. **In case the Engineer is not satisfied about the site cleanliness, he will have the right to carry out the cleaning operations and expenditure incurred in this regard will be to Contractor's account, which will be deducted from the bills**. Packing cases and packing material, except for spares shall be cleared from sites.

1.8 In order to avoid hazards to personnel moving around the equipment such as switchgear etc. which is kept charged after installation before commissioning, such equipment shall be cordoned off by suitable barriers to prevent accidental injury.

1.9 Switchgear and control/relay panels shall be installed on finished surfaces or concrete or steel sills. Proper aligning, joining of various vertical shipping sections, busbar connections, inter panel wiring etc. will be the responsibility of Contractor.

1.10 The Contractor shall take utmost care in handling instruments, relays and other delicate mechanisms. Wherever the instruments and relays are supplied separately, they shall be installed only after erection of switchgear/ relay panels is complete.

2.0 CABLING SYSTEM

2.1 All apparatus, connections and cable work shall be designed and arranged to minimise risk of fire and any damage, which might be caused in the event of a fire.

2.2 Cables shall be laid directly buried in earth, on cable trays in built-up trenches, in conduits/pipes along walls/structures/foundations/ceilings, etc. The Contractor's scope of work includes unloading, excavation, laying, backfilling, fixing, bending and terminating the cables. The Contractor shall supply the necessary material and accessories required for installation and termination of the cables which shall include but not be limited to items such as glands, lugs, terminating accessories, hardware, consumables, saddles/spacers, GI conduits/pipes, cable identification tags, protective bricks, civil materials, etc.

2.3 Buried Cables

2.3.1 Cable installation in outdoor areas such as switchgear to A2 structure shall be carried out in cable trenches/directly buried. Stabilized thermal backfilling shall be used for directly buried cables. Cabling from trenches upto junction box/equipment, etc. shall be carried out in GI conduit/pipes. Provision of GI pipe sleeves in trench wall shall be the Contractor's responsibility. Where cables cross roads or water/sewage pipes, the Contractor shall provide rows of 150 mm diameter GI pipes for passage of cables. Contractor shall also lay spare pipes for future use. LV cables shall be buried at a depth of minimum 750 mm while HV & MV 11 kV cables shall be buried at a depth of minimum 900 mm and 33 kV cables shall be buried at a depth of 1050 mm. For road crossings, the pipe for the cables shall be buried at not less than one metre depth.

2.3.2 Directly buried cables shall be laid on a 75 mm thick sand bed. The cables shall then be covered on top and at their side with sand to a depth of about 150 mm. This shall then be gently pulled down to a depth of about 100 mm above the top of uppermost cable to provide bedding for the protective concrete cable covers, which shall be placed centrally over the cables. The protective cable covers shall be of reinforced concrete. The RCC covers shall have one hole at each end to tie them to each other with GI wires to prevent displacement. The trench should be then backfilled with the excavated soil after removal of stones and boulders and well rammed in successive layers of not more than 300 mm thick, with the trenches being watered to improve consolidation, wherever necessary. To allow for subsidence, a crown of earth not less than 50 mm in the center and tapering towards the sides of the trench should be provided.

2.3.3 All cables to be routed along any particular route shall be laid at one time to avoid repeated excavation, etc. Cable route markers shall be provided for

directly buried cables at an interval of 30 m and at every bend on the route in the buried cable trench.

2.3.4 Where groups of HV, MV, LV and control cables are to be laid along the same route, suitable metallic barriers to segregate them physically shall be employed. When power cables are laid in the proximity of communication cables, minimum horizontal and vertical separation of 300 mm shall be maintained. Power and communication cables shall, as far as possible, cross at right angles to each other.

2.4 Cables In Trays

2.4.1 Cables in trays shall be cleated individually or in a group using GI saddles. Interval for cleating shall not exceed 1500 mm.

2.4.2 In case of laying on cable trays/racks, power and control cables shall be laid in separate cable trays, the order of laying of various cables being as given below:

a) HV cables on top tiers
b) LV cables on subsequent tiers
c) Control, instrumentation and other service cables in bottom-most cable tier.

2.4.3 Ladder type GI cable trays and painted rack support shall be installed in cable trenches for power cables. Perforated trays shall be used for control and instrumentation cables. Embedded flats for fixing cable tray supports shall be provided in cable trenches to support the cable trays during civil works. Where such flats cannot be used, the fixing of cable trays shall be done using anchor fasteners.

2.5 Cable Pulling

2.5.1 Standard cable grips and reels shall be utilised for cable pulling. If unduly difficult pulling occurs, the Contractor shall check the pull required and suspend pulling until further procedure has been approved by the Engineer's Representative. The maximum pull tension shall not exceed the recommended value for the cable measured by the tension dynamometer. In general, any lubricant that does not injure the overall covering and does not set up undesirable conditions of electrostatic stress or electrostatic charge may be used to assist in the pulling of insulated cables in conduit / pipes and ducts.

2.5.2 After pulling the cable, the Contractor shall record cable identification with date pulled neatly with waterproof ink in linen tags/aluminum tag and shall securely attach such identification tags. Identification tags shall be attached to each end of each cable with non-corrosive wire. The wire must be non-ferrous material on single conductor power cable. Tags may further be required at intervals on long runs of cables on cable trays and in pull boxes. Cable and joint markers and RCC warning covers shall be provided wherever required.

2.6 Each cable shall be pulled into the particular conduit/pipe. In hand holes, pull boxes or junction boxes having any dimension over 1000 mm, all conductors

shall be cabled and / or racked in an approved manner. Care shall be taken to avoid sharp bending or kinking cables, damaging insulation or stressing cable beyond manufacturer's recommendations in pulling. Cable shall be protected at all times from mechanical injury and from absorption of moisture at unprotected ends. The bending radius for various types of cables shall not be less than 15 times the overall diameter of the cable for armoured cables and 20 times the overall diameter of the cable for unarmoured cables.

2.7 Cables on cable racks and in conduits/pipes shall be formed to avoid bearing against edges of trays, racks, conduit / pipes or their supports upon entering or leaving racks or conduit/pipes.

2.8 Cables splices shall not be used except where permitted by the Engineer's Representative. Splices shall be made by Contractor for each type of wire or cable in accordance with the instructions issued by cable manufacturers and the Engineer's Representative. Before splicing, insulated cables shall have conductor insulation stepped and bound or penciled for recommended distance back from splices to provide a long leakage path. After splicing, insulation equal to that on the spliced conductors shall be applied at each splice.

2.9 At cable terminal points, where the conductor and cable insulation will be terminated, terminations shall be made in a neat, skillful and approved manner by specially trained staff. Terminations shall be made by the Contractor for each type of wire or cable in accordance with instructions issued by cable manufacturers and / or the Engineer's Representative.

2.10 Control cable termination shall be made in accordance with wiring diagrams, using proper colour codes for the various control circuit.

2.11 When control cables are to be fanned out and corded together with a cord, the Contractor shall make connections to terminal blocks, and test the equipment for proper operation before cables are corded together. If there is any doubt about correctness of connection, the Contractor shall make a temporary connection with sufficient length of cable so that the cable can be switched to another terminal without splicing. After correct connections are established, cables shall be cut to their correct lengths, connected to terminals in the specified manner, and corded together where necessary to hold them in place in a skillful manner. Jointing of cables shall be in accordance with relevant Standards and manufacturer's instructions. Materials and tools required for cable jointing work shall be supplied by the Contractor. Cables shall be firmly clamped on either side of a ‘straight through joint’ at a distance of not more than 300 mm away from the joints. Identification tags shall be provided at each joint at all cable terminations.

2.12 Where cables pass through floor or wall openings or other partitions, suitable bushes/pipe sleeves of GI shall be provided by the Contractor. The Contractor shall seal the cables at the bushes/pipe sleeves using fire resistant material.

2.13 Cable seals shall be examined to ascertain if they are intact and that cable ends are not damaged. If the seals are found to be broken, the cable ends shall not be jointed until after due examination and testing under supervision of the

Engineer's Representative. Before jointing is commenced, insulation resistance of both sections of cables to be jointed shall be checked by megger.

2.14 In each cable run, some extra length shall be kept at a suitable point to enable one or two straight-through joints to be made, should the cable develop fault at a later date.

2.15 **Conduits / Pipes**

2.15.1 Where cable trench is not available, cables shall be laid in GI conduits / pipes routed along walls / columns / beams / steel structures or buried in concrete slabs, etc. to suit site conditions. Supply and installation of GI conduits / pipes (minimum 20 mm diameter), their accessories such as bends, tees, couplers, etc., saddles, spacers, junction / marshalling boxes and GI hardware required for installation shall be included in the Contractor's scope. Interval between supports shall not exceed 1000 mm.

However, at the time of actual execution, if it is found that the cable trays (2.5 mm thick) sag, it shall be contractors responsibility to provide additional supports at no extra cost.

2.15.2 Non-metallic conduits / pipes shall be used for single core cables of a 3 phase circuits.

2.15.3 The conduits and pipes shall be properly sealed by the sealing compound/with Hessian cloth dipped in bitumen.

2.16 **Junction Boxes / Marshalling Boxes**

2.16.1 Junction boxes/marshalling boxes shall be hot-dip galvanised, weather proof with IP 55 degree of protection and shall be provided with cable glands for incoming and outgoing cables. The boxes shall be fabricated from 1.6 mm thick sheet steel and galvanised. The boxes shall be suitable for mounting on walls / columns / steel structures, etc. and shall be supplied with mounting accessories. The front covers of the boxes shall be removable and provided with gaskets. All the terminals shall be complete with insulated barriers, terminal studs, washers, nuts, etc. The boxes shall be effectively earthed. The terminals shall be suitable for terminating 2 nos. 2.5 mm^2 conductor on each side. All terminal blocks shall be rated for 1100 V, 15 A unless otherwise specified.

2.16.2 All CT terminals shall be brought to CT junction boxes by 4C x 4 sq. mm. cables respectively.

2.16.3 Marshalling box shall be provided for marshalling AC and DC supplies. AC and DC supplies shall be taken from AC and DC distribution board from control room to outside. Necessary auto changeover schemes shall be provided for ensuring continuous AC and DC supply to control room.

2.17 Typical cabling details are indicated in drawings are enclosed.

3.0 **LIGHTING SYSTEM**

In addition to the supply of lighting system, the scope of installation work shall include mounting of lighting panel, lighting fixtures and receptacles at locations as per the approved drawings. All work associated with installation such as providing and fixing of wooden blocks, ball sockets, hooks, etc. as required, drilling holes in walls, ceilings or any civil work including scaffolding, provision of ladders, etc. together with supply of hardware shall form part of the Contractor's work. All work items necessary for completing earthing connections for the lighting system shall be included in the scope of work.

3.1 Lighting panels, receptacles, light control switches, etc. shall be installed at the following heights from finished floor / ground level, unless otherwise specified.

3.1.1 Lighting panels: 1200 mm to the bottom of the panel.

3.1.2 Lighting fixtures

a) Recessed in false ceiling wherever the same is provided.

b) At ceiling level or bottom of beam level in other areas of control building.

c) Flood light fixtures at approximately 12 m on top of gantry structures or on poles/masts as specified.

d) Other types of fixtures: At suitable height subject to approval.

3.1.3 Light control switches: 1200 mm

3.1.4 Receptacles with switches

a) 1200 mm or 300 mm in indoor areas as required
b) 1000 mm in outdoor areas

3.2 All light control switches and receptacle units (connected on the same phase) at one location (such as room entrance), shall be housed in one common box.

3.3 All wiring shall be concealed inside the control room. Within the control room building, casing caping wiring shall be carried out. Space factor (ratio of total cable cross-section to internal area of conduit or casing) for conduit/casings wiring shall not exceed 40%. Size of wire chosen shall be such as to limit the voltage drop to within 2%. Wires with minimum 2.5 sq. mm. stranded copper conductor shall be used for lighting and 4 sq. mm. for power sockets. For outdoor areas minimum 2.5 sq. mm. armoured cable with stranded copper conductor shall be used. Current density in all cables shall not exceed 2.5 A/sq. mm. Wires shall be colour coded. Generally, not more than 8 to 10 lighting points shall be wired in one circuit. For calculating connected loads of various circuits, losses in the ballast shall be considered. Maximum

connected load on any circuit shall be 2500 VA for outdoor areas and 2000 VA for indoor areas. In large rooms, the lighting system shall be distributed over three phases.

3.4 Circuits for wiring of receptacles and lighting fixtures shall be separate and wiring for the same shall be done in different conduits/casings. Switches / receptacles wired on different phases shall be separated by a minimum distance of 1.8 m.

3.5 Separate conduits shall be used for normal and emergency lighting circuits. Also wires of different phases shall not be run in the same conduit. However, different lighting circuits of same phase shall run in the same conduit. Every phase wire shall have a separate neutral wire. Neutral wire shall not be looped.

3.6 For street lighting, steel tubular poles complete with fixing brackets shall be used. These poles shall be coated with bituminous preservative paint on the inside as well as on the embedded outside surface. Exposed outside surface shall be painted with one coat of red oxide primer. After completion of installation, two coats of aluminium paint shall be applied. Contractor shall supply and erect the poles (including foundation work), mount the assembled fittings, and install the necessary cabling. The Contractor's scope includes supply and installation of cables required between lighting panel and junction box mounted on the street lighting pole and between junction box and metal enclosed controlgear box. Height and type of pole shall be subject to the Engineer’s approval.

3.7 Conduits, fixtures, junction boxes etc. shall be bonded to the earthing system by 16 SWG diameter copper wire looped from lighting panel earth bus onwards. Outdoor lighting poles, junction boxes etc. shall be earthed by 8 SWG GI wire.

3.8 Typical lighting installation details are indicated in drawing .

4.0 EARTHING AND LIGHTNING PROTECTION SYSTEMS

4.1 The Contractor shall install bare earth conductors as required for the system and individual equipment earthing. All the work such as cutting, bending, supporting, drilling, brazing / soldering, clamping, bolting and connections to structures, equipment frames, terminals or other devices shall be in the Contractor's scope. All hardware and consumables such as fixing cleats / clamps, anchor fasteners, lugs, bolts, nuts, washers, brazing electrodes, flux, bituminous compound, anti-corrosive paint, etc. as required for the complete work shall be included by the Contractor.

4.2 Tap connections (earthing leads) of more than 500 mm long from main earthing grid to equipment shall be embedded in the floor by the Contractor together with associated civil work such as chipping / chasing, concreting and surfacing, etc. The concrete cover over the conductor shall not be less than 50 mm.

4.3 The scope of installation of earth conductors in outdoor areas, buried in ground shall include excavation in earth upto 600 mm depth and 400 mm width, laying of conductor at 600 mm depth, brazing as required of main grid conductor joints as well as risers upto 500 mm above ground at required locations and backfilling. Backfilling material to be placed over buried conductor shall be free from stones and other mixtures. Backfill shall be placed in layers of 150 mm, uniformly spread along the trench and compacted. If the excavated soil is found unsuitable for backfilling, the Contractor shall arrange for suitable material from outside.

4.4 Wherever earthing conductor crosses underground service duct and pipes, it shall be laid 300 mm below them. If the distance is less than 300 mm, the earthing conductor shall be bonded to such service ducts / pipes.

4.5 The scope of installation of electrodes shall include installation of electrodes in constructed earth pits, and connecting to main buried earth grids. The scope of work shall include excavation, construction of the earth pits including all materials required for treatment (salt, charcoal, chemicals, etc.), placing the electrode and connecting to main earth grid conductors.

4.6 The work of embedment of earthing conductor in RCC floors / walls along with provision of earth plate inserts / pads / earth risers shall be done by the Contractor preferably before the floors / columns / walls are cast. The embedded conductors shall be connected to reinforcing rods wherever necessary.

4.7 The scope of installation of earthing leads to the equipment and risers on steel structures / walls shall include laying the conductors, brazing / cleating at specified intervals, brazing to the main earth grids, risers, bolting at equipment terminals and coating brazed joints by bituminous paint.

4.8 Earthing and lightning protection system conductors along their run on walls / columns, etc. shall be cleated at an interval of 750 mm.

4.9 Main earthing conductor shall be buried below the trench at crossing points.

4.10 Metallic frames of all electrical equipment shall be earthed by two separate and distinct leads and then connected with earthing system.

4.11 Neutral of a transformer shall be earthed to two separate earth electrode pit by two separate earth leads.

4.12 Crane rails shall be connected to the earthing system.

4.13 An earthing mat shall be provided under the operating handle of the disconnector. Operating handle of the disconnector and the supporting structure shall be bonded together by a flexible connection and connected to earth grid.

4.14 Metal pipes and cable conduits shall be effectively bonded and earthed by earthing clamps efficiently fastened to the conduit at both ends.

4.15 Neutral connection shall never be used for equipment earthing.

4.16 A separate earth electrode shall be provided for each lightning arrester and for each lightning conductor down comer.

4.17 Cable sheaths and screen shall be bonded to the earthing system.

4.18 Armour of multicore cables shall be bonded to earthing system at both ends, while that of single core cables shall be earthed at source end only. The size of conductor for bonding shall be appropriate with the system fault current.

4.19 Conduits, fixtures, junction boxes, etc. shall be bonded to the earthing system by 16 SWG diameter copper wire looped from lighting panel earth bus onwards. Outdoor lighting poles, junction boxes, etc. shall be earthed by 12 SWG copper wire.

4.20 Street light pole and junction box shall be earthed with 12 SWG copper wire tapped off from the 25 x 3 mm copper earthing conductor to be laid along the street lighting cable.

4.21 All metallic parts such as transformer, fence, gate, etc. shall be properly earthed.

4.22 Wherever earthing conductor passes through walls, galvanised steel pipe sleeves shall be provided for the passage of earthing conductor. The pipe ends shall be sealed by the Contractor, by suitable water-proof compound. Water stops shall be provided wherever earthing conductor enters the building from outside below ground level.

4.23 All connections in the main earth conductors buried in earth / concrete shall be brazed type. Connections between main earthing conductor and earth leads shall also be of brazed type. Connection between earth leads and equipment shall be by two bolts.

4.24 Installation of lightning conductors on the roof of buildings shall include laying, anchoring, fastening and cleating of horizontal conductors, grouting of vertical rods wherever necessary, laying, fastening / cleating / brazing of the down comers on the walls / columns of the building and connection to the test links to be provided above ground level.

4.25 The lightning protection air termination rods and / or horizontal air termination conductors shall be fixed in a firm manner. The necessary accessories such as cleats, clamps, brazing materials, bolts, nuts, shall be supplied by Contractor.

4.26 Air termination systems shall be connected to earthing system by down conductors. There shall not be any sharp bends, turns and kinks in the down conductors.

4.27 All joints in the down conductors shall be of brazed type. All metallic structure within 1 metre of down conductors shall be bonded to lightning protection system.

4.28 Every down conductor shall be provided with a 'test link' mounted on wall / column at about 1000 mm above ground level housed in a 16 SWG GS enclosure. The test joint shall be directly connected to the earth electrode.

4.29 The lightning protection system shall not be in direct contact with underground metallic service ducts, cables, cable conduits and metal enclosures of electrical equipment. However, all metal projections, railings, vents, tanks, etc. above the roof shall be bonded together to form a part of roof grid.

4.30 Lightning protection system down conductors shall not be connected to other earthing conductors above ground level. In addition, no intermediate earthing connection shall be made to lightning arresters and transformer, whose earthing leads shall be directly connected to electrode pit.

4.31 The earth conductor below ground level shall be MS while that above ground shall be GS. The connection between MS and GS shall be made above ground.

4.32 **Earth electrodes and pit**

4.32.1 Treated earth pits shall comprise of treatment material such as salt and charcoal or any other conductivity enhancing compound. Treatment material placed around the electrode shall be finely graded, free from stones and other harmful mixtures. Backfill shall be placed in 150 mm thick uniformly spread and compacted layers. If excavated soil is found unsuitable for backfilling, the Contractor shall arrange for a suitable soil from outside.

4.32.2 Earth electrodes shall be fabricated from minimum 40 mm diameter, 3m long, heavy gauge MS/GI pipe. The minimum spacing between adjacent electrodes shall be 6 m. Design and constructional details of electrode pit shall be subject to the Engineer's approval.

4.32.3 Electrodes shall, as far as practicable, be embedded below permanent moisture level.

4.32.4 Test pits with concrete covers shall be provided for periodic testing of earth resistance. Installation of electrodes in test pits shall be suitable for watering. The necessary materials required for installation of test pits shall be supplied and installed by Contractor. The installation work shall also include civil works such as excavation / drilling and connection to main earth grid.

4.32.5 Treated earth pits shall be treated with suitable treatment material mentioned above, if average electrical resistivity of soil is more than 20 ohm metre.

4.32.6 Typical earthing installation details are indicated in the drawing.

TESTING AND COMMISSIONING

5.0 SCOPE

5.1 The Contractor shall carry out commissioning tests/completion checks in the presence of a engineer appointed by the Employer/Engineer. The commissioning engineer may verify any commissioning tests/completion checks to satisfy himself that the plant is fit and sound. The evaluation of test results and decision passed by the commissioning engineer regarding the test results will be final and binding on the Contractor. Any additional tests or repetition of tests to establish satisfactory operation of any equipment shall be carried out by the Contractor if so desired by the commissioning engineer at no extra cost. The test report needs to be signed by the engineer appointed by the employer, which shall be submitted during handing/taking over.

5.2 The commissioning tests/completion checks to be carried out shall include, but not be limited to, those described in subsequent paragraphs, as applicable to the individual equipment / system.

6.0 COMPLETION CHECKS/ COMMISSIONING TESTS

6.1 Preliminary Checks

a) Name plate details according to approved drawings / specifications
b) Any physical damage or defect and cleanliness
c) Tightness of all bolts, clamps and connections
d) Oil leakages and oil level
e) Condition of accessories and their completeness
f) Clearances
g) Earthing connections
h) Correctness of installation with respect to approved drawings / specifications
i) Lubrication of moving parts
j) Alignment
k) Correctness and condition of connections

6.2 General tests

In general, the following tests shall be carried out on all the equipment / systems, as applicable.

a) Insulation resistance measurement
b) Dielectric tests
c) Phase sequence and polarity
d) Voltage and current ratios
e) Vector group
f) Resistance measurement of winding, contacts, etc.
g) Continuity tests
h) Calibration of indicators, meters, relays, etc.
i) Control and interlock checks
j) Settings of equipment and accessories

k) Checking of accuracy / error
l) Checking of operating characteristics, pick-up voltages and currents, etc.
m) Operational and functional tests on equipment, accessories, control schemes, alarm / trip / indication circuits, etc.
n) Measurement of guaranteed / approved design values including lighting levels, earth resistance measurement, etc.
o) Complete system commissioning checks

6.3 Among other commissioning tests, the following shall be carried out at site after completion of installation. Contractor shall ensure use of calibrated test equipment having valid calibration test certificates from standard laboratories traceable to National Standards / International Standards. All tests shall be carried out in the presence of Engineer's representatives.

6.3.1 Transformers

Test the transformer oil for tan-delta, acidity, resistivity and dissolved gases, Capacitance and tan delta test of condenser type bushings, before assembly.

Test the transformer for the following:

a) Voltage Ratio test on all taps.
b) Short circuit impedance at full winding
c) Magnetic balance at full winding
d) Core loss at service tap at low voltage
e) Capacitance and tan delta
f) Operational check on Transformer OLTC
g) Operational Check of all mechanical relays used for Buchholz, OTI, WTI, etc
h) Transducer check as described in SCADA system.

6.3.2 Circuit Breakers

Check control wiring for correctness of connections, continuity and IR values, contact resistance as all three phases, Breaker closing and tripping time, Simultaneous closing of all three phases, Check electrical & mechanical interlocks are satisfied.

6.3.3 33/ 11 kV Indoor switchgear Circuit Breakers

Check alignment of breaker trucks for free movement, Check correct operation of shutters, Check control wiring for correctness of connections, continuity and IR values, contact resistance as all three phases, Breaker closing and tripping time, Simultaneous closing of all three phases, Check electrical & mechanical interlocks are satisfied.

6.3.7 Distribution Boards

Power frequency high voltage test, insulation resistance test, operation tests.

6.3.8 Voltage Transformers

Open delta test with low voltage, wherever required, measure core loss from LV side, Voltage ratio measurement with low voltage

6.3.9 Current Transformers

Capacitance and tan delta test, Magnetization characteristics, Current Ratio measurement.

6.3.10 Relays

Check of external wiring, relay settings, Secondary current injection and trial tripping

6.3.11 Cables

All cables shall be tested for insulation resistance before and after terminating / jointing.

Cable core shall be tested for

a) Check details as per specification
b) Check for physical damage
c) Absence of cross phasing
d) Megger test between each core and armour/sheath
e) Insulation resistance to earth
f) Insulation resistance between conductors
g) Connections
h) High voltage test

6.3.12 Lighting System

Commissioning tests stipulated in applicable standards and code of practice covering all lighting system equipment

6.3.13 Earthing System

Continuity of all conductors and joints shall be checked. The Engineer's representatives may ask for earth continuity tests, earth resistance measurements and other tests, which in his opinion are necessary, to prove that the system is in accordance with design, specification, code of practice and electricity rules. Earth grid resistance value should be not greater than one ohm.

7.0 TAKING OVER

7.1 No item of the entire Works will be certified for 'Taking over' unless it has passed all the tests.

7.2 A 'Taking Over' Certificate for Works will be issued only after the requisite documentation of commissioning tests are duly compiled and approved by the Employer / Engineer.

Section 2E – Drawings, Test Certificates, O&M manuals

SCHEDULE 2 E - DRAWINGS, TEST CERTIFICATES AND OPERATING AND MAINTENANCE MANUALS

1.0 DRAWINGS

1.1 General

1.1.1 Separate drawings shall be prepared and submitted for each equipment.

1.1.2 All drawings to be furnished by the Contractor shall be in standard size of sheets with maximum size being A0. Basic GA drawings of all systems shall be in A0/A1/A3 file. Drawings shall contain the following particulars in the title block at lower right hand corner in addition to the Contractor's name, date, scale, drawing number, drawing title etc.

a)	Client	:	Electrification Division, Distribution Construction Department, Distribution Services, Bhutan Power Corporation Limited
b)	Project Title	:	Supply & Construction of UG DISTRIBUTION NETWORK for MONTANGA INDUSTRIAL PARK, SAMDRUPJONKHAR
c)	Project No.	:	BPC/DS/DCD/ED/C-06

1.1.3 A blank space of size 100 mm x 100 mm shall preferably be provided for the Engineer's approval stamp and provision shall also be made by way of a block for details of revisions to be recorded. The drawing no. shall be marked with a subsequent revision no. every time the drawing is revised. The drawing title shall also identify name of the substation/site.

1.1.4 The equipment and systems, which are to be bought out from the sub-vendors, are also required to be approved by the Engineer prior to manufacture. The relevant technical literature and drawings pertaining to such equipment and systems shall be submitted for approval.

1.1.5 Three copies (One original and two copies) of the drawings shall be submitted. Contractor shall ensure that the contents on copies of drawings are legible and are complete with all details. Drawings that are not legible or are incomplete will not be reviewed.

1.1.6 One copy of reviewed/approved drawings will be furnished to the Contractor. Drawings returned not approved/approved with comments shall be resubmitted for review/approval till the final approval is obtained. Delays caused by submission of incomplete/incorrect drawings shall be to Contractor's account.

1.1.7 Drawings submitted by sub-vendor/sub-contractor shall carry Contractor's approval stamp and the Contractor shall be responsible for their contents, accuracy and completeness.

1.2 **Detailed Drawings**

1.2.1 The Contractor shall submit to the Engineer all equipment data and detailed drawings. These shall include general arrangement, details of equipment, foundations, cable routing, openings in walls and floors, wiring diagrams, cable schedules, interconnection diagrams, etc. necessary for the erection of plant. These drawings/data having been corrected or amended as necessary based on the Engineer's comments shall become the 'Approved' drawings/data to be used for manufacture and erection of plant.

1.2.2 Minimum details required on drawings of different categories are given below:

List of Drawings : A detailed list of drawings which the Contractor proposes to prepare for each substation/site indicating therein drawing nos. and titles.

Programme :

i. All activities from the start date upto commissioning shall be included. Separate programmes shall be furnished for each of the activities of each substation/ site.

ii. Earliest and latest occurrence of each activity.

iii. Constraints, if any.

(The activities for each of the items shall essentially cover time-table for activities such as placement of order with sub-vendors, engineering, submission of drawings, review and approval by the Engineer, manufacture, inspection, delivery, erection, testing and commissioning. All events shall be represented in a proper sequence of occurrence with due consideration for inter-dependent activities and all periods shall be counted from the start date).

Type of Drawing		**Minimum Details Required**
Single line diagrams	:	i. All equipment connections with ratings, polarities, protection and metering details etc.
		ii. Cable details for all circuits.
		iii. Details of relays, meters and major components associated with each circuit.
		v. Reference drawings.
General	:	i. Dimensional layout drawings Arrangement covering complete layout (Equipment, cabling, earthing, lightning protection, lighting, etc.)

ii. Plans and sections as required to show details access space/ clearances, etc.

v. Reference drawings

In addition to the above, the Contractor shall also submit adequate copies of all relevant supporting literature/catalogues.

1.3 **Record Drawings**

1.3.1 Within eight (8) weeks of successful commissioning tests, the Contractor shall furnish the 'Record' drawings. Submission to and approval by the Engineer of the 'Record' drawings shall be pre-requisite for the 'Taking Over' Certificate. The drawings shall show the whole Plant as installed and shall include electrical/mechanical and civil components with schematic and wiring diagrams for all items of electrical equipment included in the Works. The record drawings shall be furnished in neatly bound volumes. Reduced copies of the relevant drawings shall be included in the operating and maintenance manual.

1.4 **Specific Requirements**

1.4.1 Following information/ drawings shall be submitted after the award of Contract for approval of the Engineer:

a) Updated program along with the list of drawings.

e) 33 kV switchgear (RMU and CSS):

i. Complete assembly drawing of the switchgear showing plan, elevation, and location of cable terminations and control cable terminal blocks for external wiring connections as well as sectional view of each type of panel, such as breaker, busbar, cable and metering sections.

ii. Foundation plan showing the location of channel sills, foundation bolts and floor openings.

iii. Schematic diagram (AC and DC) for control, protection, indication, alarm and trip circuits, relays, instruments, space heaters etc. for each type of feeder.

iv. Single line diagram with details of busbars, components, cable sizes and detailed bill of material with makes etc. for each feeder.

v. Complete wiring diagrams including terminal wiring designation.

vi. Cable termination details with dimensions.

vii. Manufacturer's catalogues/literature etc.

f) 415 V AC and 110 V DC distribution boards, lighting panels etc.

i. Fully dimensioned general arrangement drawings for each of the above complete with plan, elevation and sectional views and complete bill of material, foundation drawing and cable entry details.

ii. One line diagrams

iii. Block logic diagrams

iv. Schematic diagrams for all power, control, protection and indication circuits.

v. Alarm annunciation scheme drawings.

vi. Wiring diagrams.

vii. Manufacturer's catalogues/literature etc. for numerical relays and all items.

j) Lighting system

Lighting layout drawings for indoor and outdoor areas showing layout of lighting fixtures, conduit/cables, lighting circuit distribution scheme, complete bill of material, locations of control switches, receptacles, etc. and mounting details for fixtures, switches and receptacles as well as manufacturer's catalogues/literature showing dimensions, weights, light distribution diagrams (zonal and isocandela), etc.

k) Earthing and lightning protection systems

Layout drawings for earthing and lightning protection systems showing earthing grid, locations of earth electrodes, routes of conductors, interconnections, earth leads to various equipment, bill of material etc.

l) Miscellaneous systems

Detailed general arrangement, schematic and other drawings, bill of material and manufacturer's catalogues/literature.

m) A schematic-wiring diagram and general-arrangement drawing of the AR offered.

n) Typical installation drawings

Cabling, lighting, earthing and lightning protection as well as miscellaneous system drawings showing all necessary details.

1.5 **Submission of Drawings**

1.5.1 The list of drawings and the programme shall be submitted within 45 days from the start date of the project.

1.5.2 All other drawings shall be submitted progressively thereafter within a period of 90 days. Sequence of drawings to be submitted within the above period shall be finalised with the Engineer in advance.

2.0 **TEST CERTIFICATES**

2.1 **Type Test Certificates**

2.1.1 Type test certificates for the following items shall be furnished after the award of the contract and finalizing the vendor:

a) MV and LV Cables

b) 33 kV and 11 kV switchgear, battery & battery charger.

d) All Transformers, OLTC, etc.

2.1.2 Type test certificates shall be furnished for tests carried out on similar type/design of equipment.

2.1.3 Type test certificates will be accepted, if date of the certificate is not earlier than 5 years as on date of Bid submission and in the event there is any deviation to the tested equipment from the offered equipment or the certificate is earlier then the stipulated period, the Employer reserves to get the type testing done without any extra cost.

2.2 **Routine Test Certificates**

2.2.1 Routine test certificates for all the plant items and accessories shall be furnished.

2.2.2 Routine test certificates shall be furnished in addition to test reports, which will be collected at the time of inspection.

2.2.3 Routine test certificates shall be furnished for review by the Engineer within seven (7) days after completion of inspection of relevant item or as instructed by the Engineer in case of items for which witnessing of tests is waived.

3.0 **OTHER DOCUMENTS**

3.1 Technical catalogues, descriptive literature, characteristic curves, write-up on schemes where required in support of relevant control/annunciation drawings etc. shall be furnished for all the items of plant and accessories/components.

3.2 Documents pertaining to cables shall in addition, include current ratings, derating factors, physical and electrical data, recommended bending radii etc.

3.3 Documents in respect of lighting system equipment shall include data in respect of each type of lighting fixture/switch, receptacles/miniature circuit breaker and wires to be used in circuit wiring. Data on lighting fixtures shall include dimensional drawings, cable entry facility, mounting details and weight, light distribution diagrams, light absorption and utilisation factors, lamp data etc.

3.4 Contractor shall note that the documents mentioned above shall be made available along with relevant drawings (listed in Clause 1.4.2 above) of plant items/accessories/components etc. as supporting documents to facilitate expeditious review of such drawings.

4.0 OPERATING AND MAINTENANCE MANUALS

4.1 The Contractor shall provide five (5) bound sets of approved manuals. All descriptive leaflets, instruction sheets, charts, lists, pamphlets and other documents that are used in compiling each manual shall be contained in one or more binders designed to prevent loss of contents. Each binding shall be titled with the name of the Employer, the name of the project, the Contract number, the name of the Contractor and with information to identify the subject matter and shall include a detailed index to all the literature contained therein.

4.2 The manuals shall be initially approved in draft form by the Engineer and shall cover all items of the Works. For this purpose, three (3) draft copies shall be submitted to the Engineer. Final submission of manuals shall be done after satisfactory completion of commissioning tests. A mere collection of manufacturers' descriptive leaflets will not be acceptable in satisfaction of this Clause. Information pertaining to items selected for this project shall be clearly indicated in such leaflets. The manuals shall comprise both operating instructions and maintenance instructions. The Operating manual should also highlight operation of the Plant in conjunction with the system. Thus, a general tie-up between system and equipment shall be available in the manuals.

4.3 A separate section of a manual shall be devoted to each size and type of equipment. It shall contain a detailed description of its construction and operation and shall include all relevant pamphlets and a list of parts with procedure for ordering spares. Operation of electrical equipment shall be described step by step giving the complete sequence of operation. The detailed sections of the manual, if necessary, shall contain further maintenance instructions and fault location charts.

4.4 The manuals shall be printed on A4 size sheets and shall be bound. Reduced copies of record drawings shall also be included in the manuals.

4.5 The operating instructions shall include the following:

4.5.1 Step by step directions on setting the plant to work, listing all adjustments and settings necessary for the correct functioning of the plant.

4.5.2 List of plant alarms giving possible causes for alarm initiation and sequence of remedial actions to be taken.

4.5.3 Instructions on monitoring of plant performance and sample log sheets for each plant item, to be filled by operators on a routine basis.

4.5.4 "Do's" and "Don'ts" in plant operations. Operators' attention shall be drawn to all operations considered to be dangerous to operators or likely to cause damage to the plant.

4.6 The maintenance instructions shall include the following:

4.6.1 Checking, testing and replacement procedures to be carried out on all plant items on a daily, weekly and monthly basis or at longer intervals to ensure trouble-free operation.

4.6.2 Fault locations and remedy charts to facilitate tracing the cause of malfunctions or breakdown and correcting faults.

4.6.3 A 'spares schedule' which shall consist of a complete list of itemised spares for all plant items with ordering references and part numbers.

4.6.4 A complete list of manufacturer's instructions for operation and maintenance of all bought-out equipment. The list shall be tabulated in alphabetical order giving the name of supplier/manufacturer, identification of the plant item giving the model number and the literature provided including instruction leaflets and drawing numbers.

4.6.5 Full instructions to cover the complete dismantling and re-assembly of all items of plant.

4.6.6 Part-list and drawings or exploded diagrams for such items of plant showing manufacturing tolerances, matching clearances between machined components at the time of supply, maximum wear and clearances permitted to facilitate replacement.

4.6.7 Complete list of recommended lubricants and lubricating chart, insulating oil and insulation checking/ replacement chart.

Section 2F – Contractor Safety Program

SECTION 2F - CONTRACTORS SAFETY PROGRAMME

1.0 **SAFETY ORGANISATION**

1.1 **Safety Policy**

The Contract Organisation shall have a written health and safety policy issued by the Chief Executive of the Organisation; appropriate to the scale and nature of the risks involved in the contract works. A copy of the Policy shall be made available to the Employer at the time of contract in evidence of Contractor's commitment to management of employee's health and safety and compliance to Statutory and regulatory requirements. The Policy along with its Component operation procedures shall be evidenced as working document publicised among Contractor's and his Sub-contractors' employees through appropriate language/s. All Contractors' employees shall be familiar with the Safety Policy and their role and obligations in its implementation. The Policy shall meet the relevant statutory and regulatory requirements and the requirements of the Employer. The Policy shall periodically be reviewed for updating with respect to new and emerging legal and other requirements.

The contractor shall also BPC safety instructions which will be given successful contractor.

1.2 **Safety Representative**

a) Contractor shall appoint a Safety Representative (SR) meeting statutory competence requirements, with a minimum experience of five years of safety management in comparable contracts, approved by the Employer on the basis of his qualification and experience. The SR shall give his whole time to the superintendence of the Health and Safety Programme of the Contractor.

b) The Contractor shall also nominate in writing competent Safety Appointees from different disciplines to assist SR in implementation of health and safety measures in their routine contract works. The SR shall have sufficient authority to direct Contractor's or his Subcontractor's personnel to meet health and safety requirements and to stop performance of work until such requirements are met.

1.3 **Employee consultations, Safety Committee and communication**

a) Contractor shall ensure full involvement of all his employees recognising their right to consultation on health and safety matters. The safety appointees of the various areas, in conjunction with the SR shall be responsible for ensuring employees' involvement through routine safety inspections, hazard and risk assessment in new and changed works and their control. Contractor shall maintain appropriate operating procedures to guide these requirements.

b) The Contractor shall also appoint a Safety Committee (SC) comprising of Safety Appointees from the various areas under the chairmanship of the SR .The committee shall meet at periodic intervals to discuss the status and adequacy of the safety management, and any safety concerns of the employees. The committee shall also formulate and validate the safety procedures incorporating controls to prevent or mitigate hazards and risks before submission for approval by Employer / Engineer. The minutes of SC meeting shall be submitted to the Employer / Engineer. SR shall maintain the records of the meetings.

c) Contractor shall communicate to the employees regularly on job hazards applicable to their tasks in hand. Safety Appointees (SA's or any of SR's nominees) shall hold 'Toolbox talks' for this purpose on a routine basis before undertaking any safety critical and / or non-routine activities. Weekly meetings of the Contractor and his Subcontractor attended by the SR and SA's shall include safety as a key item in the agenda to discuss hazards and risk assessments, Job safety analysis, control procedures and to review accidents and incidents (Near-miss) for remedial measures to prevent such occurrence. The minutes of the meeting shall be submitted to the Employer / Contractor. SR shall maintain the records.

1.4 **Contractor's safety reports**

The Contractor shall submit a monthly written report to the Employer / Engineer, which shall be due on the fifth workday of every month. The health and safety of all full time, part-time, permanent, temporary contract employees and any outsourced employee undertaking any part of the contract-works shall be included in the safety report. The report shall include the total number of working hours for the month, the number of recordable accidents and the number of lost-time accidents. A cumulative trend plot of the monthly severity and frequency rate of the reportable accidents shall be included in the monthly safety report and calculated as:

$$\textbf{SEVERITY} = \text{LOST } \frac{\text{MANDAYS DUE TO LOSS-TIME INJURIES X 1000000}}{\text{MANHOURS WORKED}}$$

$$\textbf{FREQUENCY} = \text{NUMBER } \frac{\text{OF LOST TIME INJURY X 1000000}}{\text{MANHOURS WORKED}}$$

Contractor shall arrange to display the safety statistics and the cumulative plot of severity and frequency of accidents mentioned above painted in a board prominently displayed, as a means of encouragement and assurance to all interested parties and for publicising the safety achievements.

1.5 **Contractor's accident/incident reports**

"Accident" for the purpose of this clause is defined as "Undesired event giving rise to death, ill-health, injury, damage or other loss" and "Incident" is defined as “Event that gave rise to an accident or had the potential to lead to an accident”. An accident where no ill health, injury, damage or other loss occurs also referred to as "near-miss". Incident includes near miss.

The Contractor shall report orally, to Employer and Engineer regardless of their extent, duration and severity, immediately on occurrence of all accidents resulting in:

a) personal injury,
b) property damages,
c) Fires,
d) spills and
e) Near misses.

Contractor shall submit the accident / incident report in writing to Employer / Engineer within 24 hours of its happening in the form as prescribed by the governing statute or in the absence of which, in the form prescribed by the Engineer. Contractor shall detail in the Accident / Incident report, the particulars of the dangerous occurrence leading to the accident, lost time of absence due to accident, root cause analysis and the corrective and preventive actions to prevent such recurrence. In addition, Contractor shall include his estimate of the impact of accident on project schedule. Incidents shall also be reported in the same manner identifying root cause/s to eliminate such potential occurrence or risks.

1.6 **First - aid personnel and facilities**

a) The contractor shall make available first-aides, first-aid boxes and / or first aid stations as per statutory requirements. The persons holding current certificates of competency of recognised institutions in prescribed numbers as per any governing statute and in the absence of such regulatory requirement a minimum of two first-aides for each area of work for every hundred workmen shall be available. First-aides' names shall be prominently displayed.

b) The first -aid boxes shall display contents of medical and medicinal articles with quantity maintained, which shall be in accordance with governing statute. Nominated first-aider shall replenish stock promptly.

c) The first-aid refresher training shall be provided at least once in a year and all employees shall be encouraged to undergo first-aid training. A record shall be kept of all first aid treatments with particulars of treatment and personnel providing the treatment.

1.7 **Ambulance room and ambulance vans**

Employer shall arrange for an ambulance room and an ambulance van directly or outsource the facilities meeting the governing statutory needs for prompt transportation of serious cases of accident and or sickness to the Hospital. Such facilities shall be maintained in good repair and equipped with facilities such as dry powder type extinguishers, flashlights Portable Oxygen Unit, self-contained breathing apparatus, etc as prescribed by the governing statute.

1.8 **Induction and job-safety training**

a) Contractor shall maintain a procedure for identification of the training needs and training his employees to create a health and safety conscious work force that will comply with the law and safety requirements of the Organisation. He shall also maintain a procedure for safety induction and initial training as well as follow-up training on the job safety for new entrants. All employees shall receive effective training and periodic refresher training on the operation control procedures specific to their tasks designed to control the job-safety risks. A booklet of such operation control procedures and safety rules with need based pictorial illustrations shall be made available to all employees who are to learn and be familiar with such procedures. All training shall be monitored for effectiveness as per established procedures. Contractor shall maintain records of all training.

b) Safety Representative and Safety Appointees shall conduct regular fortnightly or weekly mock-safety drills for different imaginary accident scenarios, in premeditated work so as to provide on-job training such as:

i use of safety appliances such as water monitors, hydrants, hydrant pumps, fire-hoses, extinguishers, breathing apparatus and safety harness for working at height,
ii response to health & safety emergencies,
iii fighting fires using different equipment and
iv first aid

Participants shall receive training during mock-drills through role-play of their normal expected tasks during emergencies and fire fighting. The degree of demonstrated ability in the chosen tasks during such safety drills shall be recorded as participants' competence level for planning his further training. The experience gained in mockdrills shall be used to update of operational control procedures and the training needs. The roster of participants and contents for routine mock-drills shall be appropriately planned to cover all employees in the training at least once in four months.

c) The Safety Representative and Safety Appointees shall be trained on a standardised comprehensive advanced training programme covering safety management, legal aspects, techniques of hazard identification and risk assessment and specific job-safety in various disciplines of the plant and equipment of the Contractor. The training records shall be maintained subject to audit by Employer / Engineer. Training effectiveness shall be assessed and recorded and used as input for further training plans of the employee.

1.9 **Health and Safety Promotion**

Safety posters, banners and slogans displayed for safety promotion shall be rotated at frequent intervals. The Contractor is encouraged to have safety promotion as an item in the safety committee agenda. Contractor is encouraged to include safety promotion programmes such as safety bulletins, magazines, competitions in slogan and poetry writing on safety, screening of safety films, celebration of national safety and environmental day, safety suggestion schemes and safety library, etc.

1.10 **Purchase and Procurement Control**

a) The Contractor shall maintain a procedure for control of his purchases to ensure that all safety requirements are appropriately vetted by the safety personnel during all stages of procurement including planning of specifications, inspection for acceptance and commissioning in order that threats to safety are not overlooked and appropriate attention is paid to the training of personnel in the operation of Contractor's new or changed machinery and their operation control procedures, to prevent / control risks.

b) Contractor shall exercise due diligence in appointing his Sub-contractors and outsourcing contract services that no new health and safety threats are created. Contractor shall ensure personnel of Sub-contractors and outsourced contract services are competent in health and safety management to meet the Policy requirements. They shall be made aware of the safety rules, emergency procedures and any information that will have a bearing on the safety, health and related contractual obligations

1.11 **Hazard Identification and Risk Assessment**

a) Contractor shall ensure that his key personnel and safety personnel are trained to be competent in hazard identification, risk assessment and risk control processes. Contractor shall on a routine basis identify, evaluate and control all health and safety risks especially in the hazardous work activities and also to validate the previous risk assessments. Elements such as hazard identification, evaluation of risks with existing control measures in place and estimate of tolerability of the residual risks shall be an ongoing process. Any additional / new control measures shall be designed based on this process on need basis.

b) Contractor shall maintain a Hazard Identification, Risk Analysis and Risk Control Manual (HIRARC) pertaining to all his activities duly updated as detailed above. The HIRARC manual shall be made available to the Engineer during regular inspections and audits.

1.12 **Work Permits**

The Contractor shall maintain a work permit procedure to limit the hazardous processes and high risks tasks to authorised personnel, who shall be informed of the job safety analysis and the job specific safety precautions, on issue of a work-permit. The work permit issued under the procedure shall be valid for a specified period and shall be issued only after all safety precautions are fulfilled and duly verified by SR / SA or specialists who are authorised for safety certification as a prerequisite for issue of a work permit. The work permit shall be appropriate for the purpose for which it is issued. The different work-permits are:

a) Safety Work Permit (SWP)

SWP is mandatory for working in heights, on fragile roofs such as Asbestos or such roofing works, Steel Erection, Work over water, a live substation or switchyard even if section of work is not electrically charged, Demolition, Blasting and such potentially hazardous Contract works in the opinion of the Employer / Engineer.

b) Electrical Safety permits/Lock-out and tag out (ESP: LOTO)

Contractor shall institute an electrical safety permit system to ensure safe electrical isolation. Safety permits shall not be issued until safe release tag is placed on the equipment isolated on all isolating points. The safety permit shall be returned on satisfactory completion of the job by the executing agencies duly signing off indicating that all shorts and grounds and men and materials are removed from the job and that the job is safe for energising. This is a prerequisite to energise the isolated equipment. The safety tags shall be collected in the order i.e. first the isolated equipment and lastly the tag on the main control of the equipment. The tags and permit system shall be auditable.

1.13 **Job Safety Inspection**

The contractor shall maintain a procedure for Safety Inspection at routine intervals to provide assurance that the instituted safety procedures are in place to prevent deviations from established standards that could lead to a safety

hazard and consequential risk. The Contractor shall establish appropriate standardised checklists for systematic job safety verification to ensure:

a) set standards are followed without deviation,
b) employees are competent to perform as per prescribed operation control procedures,
c) monitoring of safety of the various work areas/tasks and
d) adequacy of existing operation control procedures and practices to mitigate and eliminate risks.

Should the existing operation control procedures prove inadequate and the residual risks are higher than tolerable levels, SR shall initiate hazard and risk assessment / analysis and consultations with Safety Committee to deploy appropriate remedial measures and improved operation control procedures. Periodic inspection reports and proposed remedial measures shall be submitted to the Employer. Records of changes in processes; consultations with Safety Committee and revision of Operational controls shall all constitute objective evidence of the existence of established procedures.

1.14 **Safety Audits**

a) Contractor shall undertake periodic safety audits to confirm through investigative methods the effectiveness of the measures set out in the Safety Policy. In order to be effective such safety audit shall be comprehensively covering all aspects detailed in this specification to ensure effective Loss-control / accident prevention programme. Safety audits shall take into account the safety inspection records, remedial measures and effectiveness of the safety programme. Effectiveness of safety Programme shall be based on Contractor's effective Hazard identification and risk assessment processes for design of Operation control procedures and on the safety statistics. Audit reports and preventive actions and Safety Improvement programmes shall be submitted to Employer.

b) Employer shall retain his right to audit Contractor's Safety management System either directly by his Employees or his nominated representatives for its effectiveness.

2.0 EQUIPMENT AND SUBSTANCES AND PERSONAL SAFE-GUARDING

2.1 Mechanical Safety

a) Contractor shall ensure that all his equipment and machinery are safe to use while in motion or working. Operators shall have received training or instruction on operation of the machinery and the regulatory requirements. Contractor shall have adequate procedure to ensure the stability and securing of his working machinery during operation. He shall restrict repair and maintenance of the machinery to trained personnel and maintain records of repairs and maintenance. The equipment shall have appropriately designed means of isolating from sources of energy and shall have emergency stop control, which is easily accessible. All controls shall be clearly and uniformly marked. All operation controls, interlocks, sensing devices and guards on tools and equipment shall be functional and their status shall be regularly checked and recorded. Contractor shall provide evidence of compliance to these

requirements in any contractual write-ups submitted to Employer / Engineer for approval in respect of critical construction / contract works.

b) Contractor shall provide only good quality handtools and ensure control of condition, storage, routine inspection and use of such hand-tools. Unsafe tools such as with cracked or broken handles, mushroomed chisels and punches, worn screwdrivers, hardened hammerheads; power tools with unsafe resistance to earth or without safety guards shall be prohibited.

c) All safety ladders, scaffolding and access equipment shall meet requirements of IS 3696 and IS 4014:1967 and any such standards that the Employer / Engineer may stipulate. The safety work permits shall be issued only after ensuring that all safety requirements of access equipment are complied with. Access equipment shall be inspected on a routine basis to prevent injuries caused by falls.

d) Contractor shall ensure safety of all those concerned with lifting and those who may be affected by material hoisting, lifting and handling using various mechanical aids. All lifting equipment such as cranes, hoists, lifting shackles, hooks chains and links shall be designed as per appropriate International codes of construction. Operators shall have been trained in operation and maintenance of such equipment besides training on standard hand signals to be employed during the hoisting and lifting operations. Safe working loads (SWL) shall be marked on equipment prominently. SWL shall be evidenced to have been established by test procedures in accordance with acceptable codes of practices.

e) Riding on construction equipment, forklifts and cranes shall be prohibited unless such vehicles are provided with passenger seats.

f) Signs, barricades, barrier tapes and warning or entry restriction devices or accessories shall be provided to minimise work related risks of accidents and injuries. Signage shall meet all regulatory requirements such as The Building and other Construction Workers Act 1996, Factory Act 1948, Manufacture, Storage, Import of Hazardous Chemicals Rules under Environmental Protection Act 1986, Indian Explosives Act 1984 and Gas Cylinder Rules 1981 and Indian Electricity Act 1910 and Rules there of and any other safety requirements of Employer / Engineer, as applicable.

2.2 **Electrical equipment - Safety**

a) Contractor shall provide only such equipment for work that is electrically safe to work. Contractor shall have a procedure to identify and record all his electrical equipment in a register, with provisions to record his periodic inspections of such equipment. Inspection shall cover cables, extension leads, all electrical equipment drawing power from socket outlet. He shall identify and maintain in good working order all electrical installations such as distribution panels and major switchgear ensuring safe accessibility. A clear area shall be maintained around Panels and switchgear. The installed equipment shall be periodically inspected by qualified personnel to ensure their continued safe operating condition. Inspection shall include earth polarity checks, continuity checks and earth resistance checks. Contractor shall ensure use of flameproof and explosion proof switchgear and lighting fittings where required as per governing codes.

b) Approved earth leakage relays or alternative safety devices to relevant IS/International codes shall be used on all portable electrical hand tools. Where possible low-voltage electric power supply shall be used for handtools. Earth leakage units shall protect electrical installations in storeroom, pantry, transit rest room, Office / Record room, switchgear rooms, control room and battery room. Record of regular checks shall be maintained. Contractor shall comply with "Code of practice for earthing" as per IS 3043:1987.

c) Safety rubber matting of appropriate voltage rating conforming to IS 5424:1969 titled "Rubber mats for electrical purposes" shall be provided in front of all switchgear and power distribution panels for the safety of personnel operating such equipment.

d) Contractor shall arrange displaying signages under Indian Electricity Act 1910, such as :

i Danger notices as per IS 2551 in conspicuous places on all low, medium and high voltage installations as per Rule 35,
ii Instruction of restoration of persons suffering from electric shock in English and local languages as per Rule 44 in switchgear rooms, substations and places where electricity is used and
iii Notice prohibiting unauthorised entry in areas where electrical apparatus are used.

e) All power cables providing construction power to various constructions machinery and the connectors shall be in safe and sound condition. Cables shall be routed through cable trays supported on appropriately designed structures, duly clamped, secured and identified. Road crossing cables shall be laid in conduits buried at least 600 mm below the surface to prevent damage due to vehicular traffic. All cables shall be off the floor to avoid damage or tripping hazard. Cables shall be terminated at the switchgear and sockets in a workman-like manner to prevent loose contacts and flashover. Only safety receptacles shall be used for providing power connection to hand-tools. All switches and distribution boards shall be clearly marked. All electrical distribution and panel wiring diagrams shall be available with the electrical maintenance personnel. Contractor shall maintain a safe electrical isolation / lockout procedure.

f) Contractor shall ensure lighting circuits are not used for hand-tools. No electrical equipment shall be overloaded. Tools and test equipment used on electrical systems shall be insulated.

2.3 **Substances abuse plan**

The contractor is encouraged to have a "substance abuse programme", and pre-employment drug testing. Drinking during working hours shall be strictly prohibited. Contractor shall promote through poster and other publicity, awareness on abuse of substances such as alcohol and such depressant drugs that slows the activity of brain and spinal cord on abusive usage endangering the safety and health of users and others affected by their work.

2.4 **Hazardous substances control**

a) Contractor shall prevent all injuries, illnesses and damage to property or the environment caused by any article or substance, which proves to be hazardous. The code of practices of construction, operation, maintenance and control procedures shall meet required statutory and regulatory requirements. Personnel shall be trained on use, handling, storage and disposal of emergency spillage procedures.

b) Contractor shall detail and deploy Operational controls to reduce hazardous wastes and their disposal as required by the statute " Hazardous Waste (Management and handling) Rules 2000". Oil wastes, used oils, soil and cotton soaked in oil consequent to handling operations, grease, many class of paints, asbestos sheets and gaskets are typical hazardous wastes.

3.0 **PERSONAL SAFGUARDING**

3.1 **Personal protection equipment (PPE): general**

Contractor shall provide his employees required PPE meeting the requirements of the stated IS Specifications and Guidelines or equivalent International Standards as may be prescribed by the Engineer from time to time. Contractor shall have instituted good working procedures and practices in providing PPE, maintenance, issue and training on their use. All PPE shall be periodically checked to ensure worn so that damaged equipment are replaced expeditiously.

a) Control of use of issue, use and maintenance of PPE:

Employees shall be responsible for PPE issued to them. Contractor shall meet requirements of IS 8519: 1977 titled "Guide for selection of Industrial safety equipment for body protection" or any equivalent International Specification that the Employer / Engineer may prescribe.

b) **Head Protection:**

Contractor shall comply with requirements as per IS 2925. It is mandatory for the contractor to provide safety helmets to all the persons working at the site.

c) Eye and face protection:

Eye protection shall be worn during all operations by operators and people in the vicinity, where there is a danger of flying particles of metal such as generated during use of hand tools such as chisels, grinding, welding and cutting lathe work on brass and cast iron acid and alkali splash, and high pressure jet cleaning or insulation removal from heights using high pressure jets. Contractor shall meet the requirements of IS 8540:1978 titled "Guide for selection of Industrial safety equipment for eye and face protection".

d) Footwear:

Safety shoes boots and gumboots fitted with steel toecaps of approved quality conforming to prescribed Indian or International standards shall be used. Wearing of unsafe safety shoes such as jogging shoes, tennis shoes, slippers and sandal etc. shall be prohibited. Contractor shall meet the requirements of IS

10667:1983 titled ”Guide for selection of Industrial safety equipment for protection of foot and leg".

e) Protective clothing:

Contractor shall prevent hazards of loose clothes worn by workmen getting caught in moving machine parts. Loose and thin garments such as Dhoti and pyjamas shall be prohibited. While Contractors shall ensure that all workmen wear long sleeved shirts, jackets or the like with the sleeves rolled down and secured at the cuff, long pants / trousers extending upto the top of the safety shoes so as to prevent injuries caused by contact with heat, cold abrasive and sharp surfaces shall be strictly enforced. Contractor shall meet the requirements of IS 8990:1978 titled “maintenance and care of industrial safety clothing.”

f) Hand Protection:

Contractor shall provide appropriate hand gloves as per IS 8807:1978 titled: ”Safety equipment for protection of arms and hands” to prevent injuries to hands during work. Contractor shall maintain appropriate inventory of gloves for different applications like acid / alkali handling, general-purpose work gloves and asbestos or heat resistant hand gloves, etc.

g) Safety harness : Fall arrest :

Contractor shall provide safety harness or means of restraint such as safety belts, harness and lifelines, etc to workmen engaged to work in heights such as Open – sided Floors, Open-sided scaffoldings, floor and roof openings, overhead construction works of various nature, etc where there is a falling hazard of six feet or above. Storage, issue wearing and maintenance of safety harness shall be under strict supervision and records shall be maintained. All fall arrests shall consist of full-body harnesses, lanyards with shock absorbers, lifelines, rope grabs and associated hardware. Two alternate lanyards shall be used to facilitate tying off at a new location before disconnecting from the previous location’s of practices for safety harnesses and fall arrests shall conform to IS 4912:1978, IS 11972:1987, IS 8519:1977 or equivalent International codes.

h) Falling object protection:

Where work is in progress in elevated areas; barricades, barrier tapes signs and such entry restriction devices shall be used to keep area below clear of personnel to prevent injury due to falling objects. If work is required in the area below elevated work area, it shall be scheduled at a time different from elevated works. The workmen below shall be protected from falling objects by the debris net or a catch platform with an adequate toe board to prevent material from falling off. Use of safety net for elevated works shall be considered in the work-permits where appropriate. Where a lift is made above a working area, the area below the path of the lift shall be cleared of personnel during the lift and barricaded and guarded to prevent entry of persons generally in conformity with IS 4912, IS 11972 and IS 13416 for "protective barriers in and around building and preventive measures against safety hazards in work places and safety requirements for floor and wall opening, railings and toe-boards".

i) Hearing conservation:

Contractor shall ensure reasonable precautions are taken to avoid injury to the hearing of the employee. All noise levels shall be controlled within 85 dBA. Contractor shall identify noise areas where noise levels exceed prescribed safe level for arranging for appropriate Engineering revision. Where this is not feasible, appropriate Earmuffs or protectors shall be provided to workmen ensuring those wear them exposed to noise levels beyond safe levels. Periodic hearing acuity tests shall be conducted on such persons exposed to high noise levels to ensure that they do not suffer any hearing impairment` as per requirements of IS 8520: 1977

3.2 **Manual handling & ergonomics:**

a) Contractor shall have procedures to identify risks involved in manual handling, operation and tasks. He shall ensure appropriate training to prevent any possible injury. Full use of mechanical aids shall be made to avoid risks arising out of such manual handling. Employees shall be adequately trained on such manual tasks and related safety precautions to reduce the risk of injury to personnel engaged in such work.

b) Contractor shall undertake ergonomic study of manual operations to prevent musculoskeletal injury during manual handling, besides visual fatigue and mental stress giving considerations to matters such as seating, lighting and ventilation, etc.

4.0 **FIRE PROTECTION AND PREVENTION:**

4.1 **General Requirements :**

a) Risk assessments shall be carried out to identify potentially vulnerable areas to provide sufficient quantities of correct type of extinguishers and ancillary equipment to deal with various types of fire hazards.

b) Where required by the contract, Contractor shall provide appropriate type of extinguishers close to areas of fire hazard but not too close such that they are cut off from use during a fire. Water based extinguishers shall not be positioned close to or used on electrical equipment.

c) Extinguishers shall be marked / labelled and recorded with location particulars in a register. They shall be inspected at monthly intervals to ensure they are in operable sound condition. There shall be a systematic plan for servicing, repairing and recharging fire extinguishers and for recording such dates on the register and equipment.

d) The location of fire fighting equipment shall quickly and easily be identifiable especially in emergencies in a conspicuous manner painted as high as possible to identify the location of the extinguisher to prevent it from being obscured by machinery and goods stacked in front and to return the equipment to its location after emergency use in other locations. In order to ensure this, "Keep Clear" area shall be demarcated and maintained. Location plans of extinguishers and fire-fighting equipment shall be prominently displayed when desired by the Employer.

e) SR and SA shall be trained on fire fighting techniques who shall co-ordinate and control fire protection and prevention programmes.

f) Where required by contract, Contractor shall maintain alarm systems powered by mains and by battery for back up. Where required by the Contract, emergency lighting shall be provided to aid evacuation in poor lighting conditions following the alarm. The alarm system shall be made known to all employees.

g) A clear written procedure for action in the event of fire should be produced. Fire teams and Hose teams shall be identified and their responsibilities during emergencies shall be detailed in writing. Personnel shall be trained on their fire duties and use of fire-fighting equipment. Regular drills shall be conducted to test procedures and to validate them. Fire instructions and emergency procedures shall be displayed throughout the premises. Emergency response procedures are detailed below under Clause 5.0.

h) A means of escape shall be provided in all work areas and storages and maintained and kept free from obstruction. All exits shall be clearly marked and kept unlocked whilst the premises are in use. Escape routes shall be protected from fire.

4.2 **Security :**

a) Where required by the contract, Security shall do all that is reasonably practicable to ensure the safety of employees and property of the company in the face of accidents by fighting fires, and containing losses due to pilferage, theft, vandalism and industrial espionage both by employees external elements. Security personnel shall be appropriately competent, receive adequate safety training. Security shall routinely report on a standardised basis on aspects such as violation of fire-protection rules, use of alcohol and narcotic drugs, condition of security fencing, floodlighting and storage, etc.

b) Where the project is located where a number of other companies are in operation, Contractor shall plan for mutual assistance programmes in cases of emergencies, as are practiced in the area in conjunction with Employer.

c) Where common boundaries exist between companies, contractor in conjunction with Employer shall co-ordinate security control over common factors such as Floodlights, Fencing, and pipelines containing gas, fuel and electricity.

d) Security shall be represented in Safety committee through a safety appointee nominated from the area.

5.0 EMERGENCY PLANNING / EMERGENCY RESPONSE (ER)

a) Contractor shall plan to deal with emergencies (ER) specific to the job site. ER shall be written and communicated to all employees. ER shall identify for the potential and responses to incidents and emergency situations and for preventing and mitigating the likely illness and injury that may be associated with them.

b) The Contractor shall review his emergency preparedness and response plans and procedures in particular after occurrence of incidents or emergency operations.

c) Contractor shall designate his emergency team with their duties during emergencies defined, including those of the hose teams, medical personnel, first-aiders and security. Contractor shall maintain a procedure as to how his emergency organisation shall liaise with Employer's representatives in ER.

d) The Contractor shall also periodically test such emergency procedures by conducting Mock-drills and use the experience for updating the emergency Plan and for training the Employees on the perceived competence needs.

e) The emergency Response Plan of the Contractor shall be under the control of the SR who shall be able to co-ordinate with Employer for liasing with Government agencies, neighbouring industries and community

f) The plans shall be designed to allow people to work under disaster conditions when normal services such as telephone, water, light, power, transport and sanitation are not available and first aid and fire fighting facilities are not able to cope with sudden demand on services.

g) The telephone numbers, ambulance, Police; Managers and Employer's key executives shall be prominently displayed in the identified Emergency Response Centre.

6.0 PREMISES AND HOUSE -KEEPING

6.1 Orderly work-place

Contractor shall maintain a well-managed safe working place in sound clean condition. Contractor shall ensure that there is a place for everything and everything is in its place so that optimum use is made of valuable floor space with commensurate cleanliness and reduced handling time. He shall ensure that his entire infrastructure including temporary and semi-temporary buildings are kept clean and have good repair.

6.2 Good lighting (natural and artificial):

Contractors shall provide lighting (natural or artificial) to enable that work processes are carried out safely. Artificial lighting shall be adequate especially in the nights and emergencies. The lumen levels shall meet the statutory requirements.

6.3 Ventilation (natural and artificial):

Contractor shall ensure that workplaces are ventilated with at least prescribed amount of clean or cleaned fresh air of a suitable temperature, especially where toxic or irritating substances are present such as welding, vehicle exhaust fumes, irritating dusts, organic solvents or any other inimical atmosphere creating health hazards or safety.

6.4 Welfare and hygiene facilities:

Contractor shall provide welfare facilities to ensure a high standard of cleanliness for all activities and rest. Contractor shall provide adequate

facilities for his employees such as ablutions, toilets, change rooms, kitchens and cafeterias in a clean and hygienic state.

6.5 **Pollution to ground, air and water:**

Contractor shall strive to exceed established minimum performance norms in waste and pollution control. All drains shall be identified as clean water and foul water to aid non-armful disposal.

6.6 **Traffic routes and Aisles:**

Contractor shall arrange to separate pedestrian and vehicular including material handling equipment traffic wherever possible and maintain the routes clear of obstruction. To ensure safety of user's clear painted demarcation is encouraged as a discipline to be enforced.

6.7 **Stacking and storage practice:**

a) Contractor shall ensure stacked material is bonded on a stable and level footing capable of carrying the mass of the stack. Adequate clearances shall be provided between the sides of the stack and top to facilitate unimpeded access to service equipment like overhead wiring, cranes, forklifts, fire fighting equipment and hoses. Circular items shall be sufficiently choked with wedges and not with odd bits of materials. Freestanding stacks of gunny bags and sacks such as cement bags shall be stacked to prescribed safe-stack heights with layers formed for stable bonding, preventing slippage causing accidents. Stacking against walls shall not be permissible.

b) Contractor shall maintain the premises and surrounding areas in clean and clear manner with safe access and egress. There shall be sufficient and adequate storage racks, shelving, bins, pallets and material handling equipment to stack his construction materials such as pipes, structures and his construction enabling materials. Unwanted materials shall be promptly moved away for efficient material movement.

6.8 **Storage of Hazardous materials:**

a) Hazardous materials shall be stored on solid bases. Solid bases shall include compacted earth, pallets, concrete or asphalt platforms or paving. Hazardous materials shall be stored, stacked and secured to prevent toppling, spillage or other unintended dislodgement. Aisles and clearances shall be as detailed under 6.6 above. Hazardous materials shall be stacked in such a manner that an observer standing in the aisle can read their labels and legends

b) Each hazardous material contained hall be identified by a legible or legend as per governing statute, code or regulation. The label shall identify the item, quantity and appropriate warnings.

c) Hazardous materials which if brought in contact with each other could react or pose equal or greater hazard than either material stored alone shall be stored at a distance not lesser than twenty feet apart.

d) Warnings shall be posted and maintained in a legible condition at all access points clearly defining the specific hazardous nature of the stored materials

such as "Corrosive", Flammable", "Explosive", “Oxidising", "Compressed gas" or other hazardous nature.

e) Where hazardous materials are unloaded in Contractor's storage maintained at site in a semi-permanent installation, such installations shall be approved by relevant statutory bodies. Copies of licences for storage shall be lodged with Employer. The Containers and storages shall display quantities stored with name of the hazardous material and the UN Hazard classification label in prescribed colour code prominently painted in a conspicuous manner.

f) Contractor shall inspect the hazardous storages and installations on a daily basis and hall undertake any requisite preventive action necessary to avoid safety risks

6.9 **Storage of flammable / explosive Materials:**

a) Contractor shall secure flammable and / or explosive materials against accidental ignition.

b) Storage facilities for flammable liquids such as Petrol, Diesel, Kerosene and Lubricants as well as the quantities stored shall meet the legal and statutory requirements. They shall be stored in approved fire-resistant rooms with a sump of sufficient volume to contain any spillage.

c) The electrical fittings shall be flame -proof and on a strict maintenance schedule.

d) Containers shall be appropriately bonded in receptacles into which low flash point fuel is decanted.

6.10 **Compressed gas cylinders**

Compressed gas cylinders shall be stored and secured in the upright position at safe distances shielded from welding and cutting operations. Compressed gas cylinders in storage shall be shut off and torches, hose and manifolds removed and capped. Cylinders shall be periodically checked for leakages. Storage shall meet requirements of Gas Cylinder Rules 1981. Compressed gas storages shall be provided with safety relief valves, safety valves and rupture disc to protect them from overpressures and shall be appropriately designed to ensure their continued availability in the face of process changes.

6.11 **Scrap and Refuse Bins-Removal System**

Contractor shall ensure that he has sufficient waste bins that are identified for different wastes and maintained in clearly demarcated areas. Wastes with oily or other ignitable materials such as Oily cotton wastes and Hand gloves shall be stored separately with covers to prevent fires and shall be made of metal. Different Wastes shall be segregated and stored separately and disposed off. They shall be emptied at routine intervals to prevent that they do not overflow with wastes.

Section 2 G – List of Approved makes

SECTION 2 G - LIST OF APPROVED MAKES

1.1	**Power Transformer**	
1.1.1	Crompton Greaves	Mumbai
1.1.2	Telk	Ernakulam
1.1.3	Schneider (Areva)	Naini
1.1.4	ABB	Vadodara
1.1.5	Bharat Bijlee	Mumbai
1.1.6	BHEL	Bhopal
1.1.7	Siemens Ltd.	Mumbai
1.1.8	Kanohar Transformers	Meerut
1.2	**Distribution Transformers**	
1.2.1	Crompton Greaves	Mumbai
1.2.2	Kotsons Limited	Agra
1.2.3	Indcoil limited	Mumbai
1.2.4	Marsons limited	Agra
1.2.5	Kanohar Transformers	Meerut
1.2.6	NEEK	Nepal
1.2.7	Necon Switchgears	Punjab
1.2.8	Uttam (Bharat) Electrical	Jaipur
1.2.9	Kirloskar Electric Company	Bangalore
2.0	**33 kV and 11 kV circuit breakers**	
2.1	ABB	Vadodara
2.2	Schneider (Areva)	Kolkatta
2.3	Siemens	Mumbai
2.4	Pascal switchcare India Pvt. Ltd	Kolkatta
2.5	Crompton Greaves	Nasik
2.6	Jyoti Ltd.	Vadodara
2.7	BHEL	Bhopal
3.0	**Lightning Arresters.**	
3.1	Elpro International	Mumbai
3.2	Oblum Electrical	Hyderabad
3.3	W.S. Industries	Chennai
3.4	BHEL	Bhopal
3.5	Crompton Greaves	Nasik
4.0	**Current/Potential Transformers/ CVTs**	
4.1	Crompton Greaves	Mumbai
4.2	ABB	Vadodara
4.3	Mehru Electricals	Mumbai
4.4	Schneider (Areva)	Bangalore
4.5	BHEL	Mumbai

4.6	CGL	Arungabad
5.0	**Relays**	
5.1	Schneider (Areva)	Kolkatta
5.2	ABB	Mumbai
5.3	Siemens	Mumbai
5.4	Easun Reyrolle	Hosur
6.0	**LT and Control cables**	
6.1	Asian Cable Corporation	Mumbai
6.2	Cables Corporation of India	Mumbai
6.3	Universal Cables	Mumbai
6.4	Finolex Cables	Pune
6.5	Polycab Industries	Mumbai
6.6	KEI	Rajastan
6.7	HVPL	Delhi
6.8	Delton cables Ltd.	Delhi
6.9	NICCO Corporation Ltd.	Kolkata
6.10	KEI Industries Ltd.	New Delhi
6.11	Paramount Cables	New Delhi
6.12	Prew Cables	New Delhi
6.13	Insucon Cables	India
6.14	Havells India	India
6.15	Apar Industries	India
7.0	**HV Cables**	
7.1	Asian Cable	Mumbai
7.2	Cables Corporation of India	Mumbai
7.3	Universal Cables	Mumbai
7.4	HVPL	Delhi
7.5	Fort Gloster Inducstries Ltd.	Kolkata
7.6	KEI Industries Ltd.	New Delhi
7.7	Havells India	India
7.8	Apar Industries	India
8.0	**AC & DC Distribution Boards**	
8.1	Controls & Switchgear Co	Delhi
8.2	Pecon Engineering	Kolkota
8.3	Continental Engineering	Lucknow
8.4	Control and Protection	Kolkota
8.5	L&T Ltd.	Mumbai
8.6	Vikas	Lucknow
8.7	Sarvana	Bangalore
9.0	**Substation Structures**	

9.1	RPG Transmission	Delhi
9.2	L&T	Mumbai
9.3	Jyoti Structures	Mumbai
9.4	Amitava Structures	Nagpur
9.5	Advance Steel	Delhi
9.6	Mann Structural	Jaipur
9.7	Skipper Steel	Howard, WB
9.8	Swastika Steel & Allied products	Howard, WB
9.10	Bhutan Rolling Mills	Pasakha
9.11	Druk and Iron Steel (Karma TMT)	Phuentsholing

10.0 Multi Function Meters/Meters

10.1	Automatic Electric	Mumbai
10.2	ABB	Mumbai
10.3	Industrial Meters	Mumbai
10.4	Secure Meters	Jaipur
10.5	Enercon	Delhi
10.7	Schnieder	Delhi
10.8	L&T	Bangalore

11.0 Substation Hardware Fittings

11.1	Tyco Electronics (Dulmison)	India
11.2	Exalt Engg.	Mumbai
11.3	Sicamex	France
11.4	Supreme	Kolkota
11.5	IAC Electrical	Kolkota
11.6	Rashtriy Udyog	Kolkata
11.7	Indo Asiatic Corporation	Kolkata
11.8	Tag Corporation Ltd.	Chennai

12.0 Insulators & Bushings

12.1	BHEL	Bangalore
12.2	WS Insulators	Chennai
12.3	NGK Jayshree	Kolkota
12.4	Modern Insulators	India
12.5	Aditya Birla	India
12.6	Allied Ceramics	India

13 Ventilation Fan

13.1	Alstom	India
13.2	Crompton Greaves	India

14 Portable Fire Extinguishers

14.1	Steelage (Minimax)	Mumbai

14.2	Nitin	India
14.3	Vijay Fire	Mumbai

15.0 Battery

15.1	Chloride Industries Limited	Kolkota
15.2	Amar Raja Batteries Limited	Kolkata
15.3	Exide Limited	Mumbai
15.4	Standard Batteries	Mumbai
15.5	Bharat Cutler Hammer	New Delhi
15.6	Automatic Electric	Munbai
15.7	Chabi Electricals	Mumbai

16.0 Battery Charger

16.1	Automatic Electric	Mumbai
16.2	Mass Tech Controls (p) Limited	Mumbai
16.3	Chabbi Electricals Limited	Mumbai
16.4	Exide Limited	Kolkota
16.6	Electro Service (India)	Kolkota
16.7	Amar Raja Batteries Limited	Kolkata

17.0 Civil Works

17.1 Doors Closure, Floor Spring: Doorking, Everite, Acme-4C
17.2 Ceramic Tiles: Kajaria, Spartek, Nitco, Somany
17.3 Glazed Tiles: Somany, Kajaria, Johnson
17.4 Aluminium Sections: Indal, Hindalco, Jindal
17.5 Clear Float Glass/Toughened Glass: Modiguard
17.6 Pre-laminated Particle Board: Bhutan Board, Green Wood
17.7. Door Shutters: Novapan, Kitlam, Sitapur
17.8. Laminates: Neoluxe, Decolam, Formica
17.9. Plastic Emulsion, Synthetic Enamel & Other paints :Nerolac, ICI-Dulux, Shalimar
17.10. Cement Paint: Super Snowcem, Shalimar
17.11. Water Proofing Material: Cico,Killic Nixon,Pidilite,STP Ltd.
17.12. Integral Cement based water proofing: Overseas Water Proofing, Roofer India.
17.13. Reinforced Steel: Tisco, Sail, IISCO
17.14. Cement (PPC): L&T, ACC, JK,CCI, Penden
17.15. Silicon Sealent: Pidilite, Wacker
17.16. Isothanc Elastomeric Membrane: Liayd Insulation, STP Ltd.
17.17. Texture Paint: Spectrum
17.18. Cement Bonded Particle Board: Bison
17.19. Roofing Sheet : Tata, SAIL

18.0 Plumbing Works

18.1. Vitreous China Sanitary Ware: Payrryware, Hindustan Saitary Ware, Neycer, Cera
18.2. White Glazed Fire Caly Sink: Sanfire Cera, Neycer
18.3. Stainless Steel Sink: AMC, Orient, Sunag
18.4. Plastic Seat Cover of WC: Commander, Bestolite, Diplomat

18.5. Geyser: Venus Spash, Usha Lexus
18.6. CP fittings mixers, Piller taps Washer: Gem, Parko Kingston
18.7 Sand Cast Iron Pipes & fittings: RIF, NECO, BIC
18.8 GI Pipes & MS Pipe: GST, Jindal, Kalinga, Tata, Bansal, Imperial
18.9. GI fittings: Kohhi, VI, Umk, MAC
18.10 Gunmetal Valves:Zoloto Leaser, Sant, Kohhi.
18.11. Brass stop & Bib cocks: Zalato, Sant, L&K
18. 12 Ball valve with float: Zaloto Leader, Sant
18.13 Stoneware pipes & Gully traps: Perfect, Burn Hind
18.14 RCC Pipes: IS marked pipes
18.15 CI Manhole Cover: RIF, NECO, BIC
18.76 Water Tank: Sintax, Polycon, Uniplas
18.17 Mirror Golden fish, Atul Jolly, Modi
18.18 Teak Ply/Commercial: National, Kitply, Novapan, Bhutan
18.19 Mosaic Tiles: Nitco
18.20 Locks: Godrej, Harison, Acme-4C(25mm)
18.21 Flooring & Wall Tiles: Somany, Argil, Kajaria

19.0 Electrical and Wiring Materials

19.1. Lamps: Bajaj, Philips, GE, Osram, Crompton
19.2. Fluorescent lamps, CFL's: Bajaj, Philips, GE, Osram, Crompton
19.3 Mercury Vapour, Sodium Vapour lamps, Halogen lamps: Philips, GE, Bajaj, Orsam.
19.4 Luminaires/ fixtures: Bajaj, Philips, Compton, GE.
19.5 Switch & Sockets: Anchor Roma/Rider/woods, NorthWest, Crabtree, LK Fuga
19.6 MCB's: GE, Siemens, MDS Legrand, Havels
19.7 Wires: Finolex, Havells, Royal Cables, V-guard.

20 Cable Terminations: MSeal, Yamuna Power Technologies, Compaq International and Raychem.

21 UPS: Aplab, Emerson Power System, Hirel electronics, Eneron system.

22 Air Conditioners: Blue Star, Electrolux, Carrier, Hitachi

23 Note: All the material supplied in this contract shall be Class A materials and shall be delivered to the site after the proper testing/approval of the samples in case of civil works materials.