

SECTION VI – TECHNICAL SPECIFICATIONS

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GENERAL TECHNICAL REQUIREMENTS

1.1 **Project Description**

Bhutan Power Corporation Limited (BPC) intends to upgrade the following 33/11 kV Substation:

- a. **Conversion of 33 kV VCB panels by GIS at 33/11 kV Substations, ESD, Phuentsholing**
- b. **Replacement of 33 kV VCB (Outdoor type) at 33/11 kV Substations, Gurungdara, Darla.**

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
Substation	a. Conversion of 33 kV VCB panels by GIS at 33/11 kV Substations, ESD, Phuentsholing b. Replacement of 33 kV VCB (Outdoor type) at 33/11 kV Substations, Gurungdara, Darla.
Cabling System	33 & 11 kV cables up-to the takeoff structure shall form a part of the work.

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 1520 m at Gedu and 293 m at Phuentsholing.

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**

Gurungdara, Darla is accessible from Phuentsholing, Bhutan by road. The site is nearly 171 km from the Paro international airport. 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	70	28	28	2
b) 1.2/50 microsecond impulse kVp	170	75	75	6
Creepage distance mm	N/A	25 mm / kV	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 of the site 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 apart from Schedule “D”.

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. 415 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) Panel Wiring

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 mm² per lead.
- b) CT Circuit : 4 mm² 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.

p) Rubber Mats

Rubber mats, of appropriate thickness, shall be supplied and installed in front of 33 kV and 11 kV switchgear, 415 V ACDB and 48 V DCDBs.

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 welding 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.

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 its 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.

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 overlap 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 lamincoid. 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 revegetate 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 these 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 GIS panels - 15 days.
 2. Drawings for 11 kV panels - 15 days.
 3. Drawings for transformer – 15 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.

SECTION VI - B

1 – 33 KV GAS INSULATED SWITCHGEAR

1.1 SCOPE

1.1.1 The scope shall be for the design, engineering, manufacture, assembly, testing at manufacturer's works before dispatch and services for supply, insurance, transportation, delivery at project site, handling, storage and preservation at store/site, transport to place of installation, complete work of site assembly, erection, testing at site and commissioning of 36 kV SF6 Gas Insulated Switchgear (GIS). The equipment shall comprise of:

- a) Circuit Breakers
- b) Bus Bars – Single bus
- c) Current Transformers
- d) Voltage Transformers
- e) Transition between SF6 GIS and XLPE Cable terminations, operating mechanism for each equipment
- g) SF6 Gas
- h) Supporting steel structures
- i) Complete earthing system etc.
- k) Any other item which is not covered above and but required for the operation of the switchgear shall be supplied.

1.1.2 Any other equipment not explicitly mentioned herein/in the schedule of requirements but is necessary for completeness of works specified shall also be included in the scope without any extra cost. ***The equipment shall be suitable for climatic conditions and altitude as mentioned in the technical specifications.***

1.2 SYSTEM DETAILS

The following 33kV indoor GIS shall be provided at Phuentsholing, 33/11kV substation:

- (a) 1 no. of 33 kV incoming panel from/to **Substation Feeder 1** which shall be connected with 3Cx300 sq.mm XLPE aluminum cables
- (b) 1 no. of 33 kV incoming/outgoing panel from/to **Substation Feeder 2** which shall be connected with 3cx300 sq.mm XLPE aluminum cables
- (c) 2 nos. of outgoing 33 kV panels shall be connected to 2x5 MVA, 33/11 kV substation with 3Cx300 sq.mm XLPE aluminum cables.
- (d) 1 no. bus section panel.

The switchgear shall be in two bus sections, each catering to 1 incomer and 1 outgoing (transformer feeder) with bus section breaker. In addition to the bus PTs on each bus section, the incomers shall be provided with line side PTs. For the incomer feeders and bus-section, the breaker control circuit shall incorporate following suitable control schemes (LILO):

- (a) Looping out the power to substation feeder 1 at the same time charging the transformers (2x5 MVA, 33/11 kV)
- (b) Closing of incomer-2 feeder breaker (see SLD) when incomer-2 line is dead, at the same time feeding the transformers.
- (c) Synchronizing two sources (i.e when feeding from Substation Feeder 1 and Substation Feeder 2) through closing of bus coupler breaker.

These control schemes shall be duly taken care by the bidder during switchgear drawing submission.

1.3 STANDARDS

- 1.3.1 The GIS switchgear shall comply with the latest amendments/revision of the following standards or equivalent:

IEC 62271-200: High Voltage metal-enclosure switchgear
 IEC 62271-100: High Voltage AC Circuit Breaker
 IEC 60044-1: Current Transformer
 IEC 60044-2: Voltage Transformer
 IEC 62271-102: AC Disconnectors & Earthing Switches
 IEC 60376: Specification and Acceptance of new sulphur hexafluoride
 IEC - 68 (Part III) : Seismic test methods for equipments
 IEC – 71: Insulation coordination.
 IEC – 137: Bushing particulars.
 IEC -270: Partial discharge measurements.
 IEC –62271-303: Guide to the checking of SF6 taken for electrical equipments.
 IEC –62271-1: Common Clauses for HV switchgear.

- 1.3.2 If there are, in the opinion of the bidder, any contradictions between the above standards and these specifications, such contradictions shall be brought to the attention at the time of bidding.

1.4 RATINGS

- 1.4.1 The ratings and general characteristics of the GIS shall be as follows:
 (The ratings applicable to specific items of equipment are indicated in the applicable sections dealing with the equipment).

(a)	Type of Switchgear	36 kV Three phase, metal enclosed, SF6 gas insulated switchgear
(b)	Location	Indoor
(c)	FREQUENCY	50 (-2% + 1%) Hz
(d)	Rated voltage class, kV rms	36
(e)	Highest System voltage	36 kV rms
(f)	Number of phases	Three

(g)	Full wave impulse withstand voltage (1.2/50 micro sec.)	170 kVp
(h)	Rated one minute power frequency with stand voltage	
(i)	Phase to earth	70 kV rms
(ii)	Across open contacts	70 kV rms
(i)	System earthing	Effectively grounded
(j)	Rated normal current	
(i)	Incoming circuits	850A
(ii)	Out going feeder circuits	850 A
(iii)	Bus coupler circuit	850 A
(k)	Rated short circuit withstand current at rated maximum voltage for three second	Not less than 25 kA rms (symmetrical)
(l)	Rated breaking capacity of circuit breaker (min)	25 kA rms
(m)	Rated making capacity (min)	63kAp
(n)	Prospective transient recovery voltage appearing across the circuit breaker terminals	As per IEC 62271-100
(o)	Partial discharge level at $1.1 U_n/\sqrt{3}$	20 pico coulombs or less
(p)	Material of enclosure	Stainless steel
(q)	Material of bus bar	Copper
(r)	Insulation medium	SF6 gas
(s)	Guaranteed gas loss	: < 1% per annum

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

1.5 GENERAL DESIGN AND SAFETY REQUIREMENTS

1.5.1 The switchgear shall be single busbar, SF6 insulated capable of continuous operation under the climatic condition and altitude at the site.

1.5.2 The panel shall be of extendable type. The design shall be such as to enable bay extension at either end with the minimum of disturbance to the installed equipment and without complete shutdown of the switchboard.

1.5.3 The switchgear units shall be divided into several gas-filled compartments. The equipment and connections will be arranged in such a way to allow ready removal and replacement of any section with minimum isolation and disruption of adjacent pressurized sections. This feature should also permit erection and testing of extension

units with the equipment in service with the minimum of outage time required.

- 1.5.4 The pressurized compartments shall be designed to minimize the risk of damage to adjacent sections and protection of personnel in the event of a failure occurring within the compartments. Individual compartments shall be equipped with pressure relief devices.
- 1.5.5 A temperature compensated gas monitoring system with two alarm contacts shall be furnished in each gas section to provide indication and alarm of the gas condition. The gas monitoring system shall monitor the pressure and gas density of the SF₆ gas insulated apparatus. Both visual indication and alarm shall be provided with each gas pressure monitors. Alarm circuit shall not respond to faults for momentary conditions
- 1.5.6 The gas loss per annum should be not more than 0.5% in any single gas compartment. In case of extensive gas leakage during the defect liability period, BPC has the right to request the contractor to replace the parts of the assembly which caused the leakage without any cost implication to BPC.
- 1.5.7 The switchgear, which shall be of modular design, shall be fully gas insulated, all Medium Voltage parts shall be insulated with SF₆ gas. The conductors and the live parts shall be mounted on high graded epoxy resin insulators. These insulators shall be designed to have high structural strength and electrical dielectric properties and shall be shaped so as to provide uniform field distribution and to minimize the effects of particle deposition either from migration of foreign particles within the enclosures or from the by-products of SF₆ breakdown under arcing conditions.
- 1.5.8 The connecting points for the gas monitors shall also include connectors for evacuation and gas filling.
- 1.5.9 Gas barrier insulators shall be provided so as to divide the GIS into separate compartments. They shall be suitably located in order to minimize disturbance in case of leakage or dismantling. They shall be designed according to IEC 62271-200 6.103. The switchgear design shall confirm IAC AFLR. Gas section barriers shall be gas tight and capable to withstand the maximum pressure differential that could occur across the barrier. The support insulators and section barriers shall be of sufficient strength to ensure that spacing and clearances are maintained when short circuit faults occurs.
- 1.5.10 The material and thickness of the enclosures shall be such as to withstand an internal flash over without burn through for a period long enough 1000ms till the backup relay protection clears the fault. The material shall be such that it has no effect of environment as well as from the by-products of SF₆ breakdown under arcing condition.
- 1.5.11 The material used for manufacturing the switchgear equipment shall be of the type, composition and have physical properties best suited to their particular purposes and in accordance with the latest engineering practices. All the conductors shall be fabricated of copper bars of cross sectional area suitable to meet the normal and short circuit current rating requirements. The finish of the conductors shall be smooth so as to prevent any electrical discharge. The conductor ends shall be silver plated wherever required to confirm the ratings as per IEC. The contacts shall be of sliding type to

allow the conductors to expand or contract axially due to temperature variation without imposing any mechanical stress on supporting insulators.

- 1.5.12 The switchgear line-up when installed and operating under the ambient conditions shall perform satisfactorily and safely under all normal and fault conditions. Even repeated operations upto the permissible servicing intervals under 100% rated and fault conditions shall not diminish the performance or significantly shorten the useful life of the switchgear. Any fault caused by external reasons shall be positively confined to the originating compartment and shall not spread to other parts of the switchgear.
- 1.5.13 Bracings shall be provided for all mechanical components against the effects of short circuit currents. The arc faults shall be positively confined to the originating compartment and shall not spread to the other parts of switchgear.
- 1.5.14 The switchgear shall be of the free standing, self-supporting with easy accessibility to all the parts during installation and maintenance, dead front design with all high-voltage equipment installed inside gas-insulated metallic and earthed enclosures, suitably sub-divided into individual arc and gas-proof compartments at least for:
 - (i) Busbars.
 - (ii) Circuit breakers.
- 1.5.15 The arrangement of the individual switchgear bays shall be such so as to achieve optimum space-saving, neat and logical arrangement and adequate accessibility to all external components.
- 1.5.16 It should be impossible to unwillingly touch live parts of the switchgear or to perform operations that lead to arcing faults without the use of tools or brute force. All mechanical operations shall be done with the door closed.
- 1.5.17 A comprehensive interlocking system shall be provided to ensure reliable and safe operation of the substation. All interlocks that prevent potentially dangerous mal-operations shall be constructed such that they cannot be operated easily, i.e. the operator must use tools or brute force to over-ride them. Within one panel, mechanical interlocking has to be provided and the three position switch must have facilities to be operated manually.
- 1.5.18 The actual position of circuit breakers must be positively displayed by mechanical indicators visible from the operating position. It shall be possible to remove the CB without having to switch off the BB.
- 1.5.19 In general the contours of energized metal parts of the GIS and any other accessory shall be such, so as to eliminate areas or points of high electrostatic flux concentrations. The surfaces shall be smooth with no projection or irregularities, which may cause visible corona.
- 1.5.20 The fabricated metal enclosures shall be of stainless steel and have high resistance to corrosion, low electrical losses and negligible magnetic losses. All joint surfaces shall be machined and all castings shall be spot faced for all bolt heads or nuts and washers. All screws, bolts, studs and nuts shall conform to metric system.

- 1.5.21 Wherever required, the heaters shall be provided for the equipment in order to ensure the proper functioning of the switchgear at specified ambient temperatures. The heaters shall be rated for 230V AC supply and shall be complete with thermostat, control switches and fuses, connected as a balanced 3-phase, 4-wire load. The possibility of using heaters without thermostats in order to achieve the higher reliability may be examined and accordingly decided during detailed design stage but it shall be ensured that the temperature rise of different enclosures where heating is provided should be within safe limits as per relevant standards. The heaters shall be so arranged and protected as to create no hazard to adjacent equipment from the heat produced.
- 1.5.22 The sealing provided between flanges of two modules/enclosures shall be such that long term tightness is achieved.
- 1.5.23 All earthing systems will be designed to ensure safety and protection of all operating and maintenance personnel during all normal and fault conditions.
- 1.5.24 Cable termination shall be of standard quality of international reputed make.

1.6 CIRCUIT BREAKERS

1.6.1 Type and Rating

- 1.6.2 The circuit breakers being supplied shall be suitable for operation with Transformers and 33 kV Sub-transmission lines.
- 1.6.3 The CB shall be spring operated, motor charged and manually released spring closing mechanism with three pole simultaneous operations. The speed of the closing operation shall be independent of the hand-operating lever. The indicating device shall be mechanical type directly linked to the mechanism and shall show the OPEN and CLOSE position of the breaker visible from front of the cubicle without opening any doors or covers
- 1.6.4 The “TRIP” and “CLOSE” coils shall be of reliable design and low consumption. Anti-pumping relays and T-N-C switch/PB shall be provided for each panel.
- 1.6.5 Vacuum Type circuit breaker shall conform to IEC-56 and have the following performance characteristics and ratings, in addition to those stated in Clause 4.0 of this document.

(i)	Type of breaker	36 kV three-pole, metal enclosed, Vacuum Type
(ii)	Rated frequency	50 Hz
(iii)	Rated normal current: (Minimum)	
	• Bus coupler breaker	850 A
	• Transformer incomer breaker	850 A
	• Out going line breaker	850 A

(iv)	Number of poles	3
(v)	Installation	Indoor
(vi)	Temperature rise	As per IEC 694-1
(vii)	Rated short time withstand current kA (rms value of ac component) minimum	25 kA for 3 second
(viii)	Rated short circuit making current, kA (peak) Minimum	63kA
(ix)	Rated out-of phase breaking current (rms)	6.25kA
(x)	Rated short circuit breaking current	
-	Rated short circuit current	25 kA (rms)
-	Percentage of DC component	$\geq 37\%$
(xi)	System Earthing	Effectively earthed
(xii)	First-pole-to clear factor	≥ 1.5
(xiii)	Rated duration of short circuits	3 seconds
(xiv)	Total break time for any current upto the rated breaking current	Not exceeding 60ms
(xv)	Closing time	< 100ms
(xvi)	Maximum difference of time at opening of series contacts within one pole	$\pm 3\text{ms}$
-	Maximum difference of time at opening between phases	$\pm 3\text{ms}$
-	Maximum difference of time at closing between phases	$\pm 3\text{ms}$
(xvii)	Rated transient recovery voltage for terminal faults	As per IEC 56
(xviii)	Rated operating duty cycle	0-0.3 s-CO-3 min-CO
(xix)	Rated line charging	50A with maximum breaking current permissible switching over voltage not greater than 2.5pu
(xx)	Operating mechanism	Spring type

(xxi)	Rated supply voltage of closing and opening devices and auxiliary circuit	110 V DC
(xxii)	Number of auxiliary contacts	6 NO and 6 NC on each pole wired to terminal blocks in control cabinet
(xxiii)	- Number of trip coils - Number of closing coils	2 per pole 1 per pole
(xxiv)	Main contact material	Copper (with silver plate where required)

- 1.6.6 The governing data for the selection of circuit breakers shall not be limited to the above mentioned parameters but shall also take into account various provisions contained in these specifications and relevant standards.

1.7 CURRENT AND VOLTAGE TRANSFORMERS

- 1.7.1 CTs and VTs shall have polarity marks indelibly marked on each transformer and at the associated terminal block. Facility shall be provided for short circuiting and earthing the CT secondary at the terminal blocks.
- 1.7.2 CT's shall be easily accessible and interchangeable.
- 1.7.3 The CT ratios shall be furnished during detail engineering after the award of the work. All the breakers including bus couplers are to be provided with the CTs.
- 1.7.4 Identification labels giving type, ratio, output and serial numbers shall be provided for CTs and VTs.
- 1.7.5 VTs shall be of the single-phase type.
- 1.7.6 VT shall be connected by using isolators.

1.8 DISCONNECTING AND EARTHING SWITCHES

- 1.8.1 Disconnecting and earthing switches shall permit safe maintenance of any section of the equipment when the remainder is live.
- 1.8.2 The disconnecting switch and earthing switch shall be of motor driven mechanism. For safe isolation of the busbars and feeders, high speed fault making spring driven disconnecter/earth switch shall be provided. They will also have facilities for manual operation and necessary operating handles shall be provided. The mechanical operation of the disconnecter switch must be possible with door closed for operator safety.
- 1.8.3 All earthing switches shall be fully interlocked with associated circuit breaker and disconnecting switches.

1.9 CABLE TERMINATIONS

Cable termination to be located at a convenient connection height. Outer cone-type

systems shall be preferred. Outer cone type in accordance with relevant international standard for terminating cable of cross sections upto 1cx300 sq.mm upto to including 36 kV.

1.10 PROTECTION AND CONTROL SYSTEM

Refer “relays and protection” for details

1.11 INSPECTION AND TESTING

All the routine and acceptance tests as specified in the applicable standards shall be carried out on the GIS switchgear, Circuit Breakers, CT, VT, disconnecting and earthing switches. Test reports of all the bought items shall be reviewed during testing. Type test of the switchgear shall be submitted by the successful bidder during drawing approval.

1.12 COMPLETENESS OF THE EQUIPMENT

Any fittings, accessories or apparatus which may not have been specifically mentioned in these specifications but are necessary for completeness of the equipment shall be deemed to be included and shall be supplied without any extra charges to the Employer. All plants and equipments shall be complete in all respects even if the details regarding all the items are not mentioned in these specifications.

1.13 SPARES

BPC shall have option to order recommended essential spare parts as per the terms and conditions of the contract. The spare parts shall be interchangeable and shall be of same quality as that of original components.

1.14 GENERAL REQUIREMENTS

The relay shall be provided as per Section 7. The meters shall be provided as per Section 6. The control wiring, indicating instrument, control and selector switches, indicators, push buttons, termination and other equipment shall be as per Section 3. CT's and PT's requiring special manufacturing and consideration for the use in GIS shall be provided.

1.15 DRAWINGS/DOCUMENTS

In addition to the requirement of documents/drawings specified in the Volume 1, Part 2, contractor shall submit following drawings/documents after award of contract. Any additional requirement found necessary shall be submitted.

- i) Single line diagram indicating rating table, CT/VT characteristics
- ii) GA, layout and foundation drawing
- iii) Gas section diagrams/gas compartment scheme indicating all gas monitors, rated alarm/lockout pressure, location of gas barriers etc
- iv) Catalogues of all components in GIS and LV component, CT, VT gas handling unit etc.
- v) Installation manual for GIS, CT, VT, cable termination etc
- vi) Operation and maintenance manual

- vii) Factory Test Procedure for GIS, CT, VT , LV compartments etc
- viii) Site test procedure for GIS, CT, VT , LV compartments etc
- ix) Schematic diagram of GIS
- x) Interlocking drawings
- xi) Any other drawing/document found necessary during engineering and site installation stage for proper coordination

2. RELAY AND PROTECTION

2.0 The relay provided shall be as mentioned below. Besides, numerical relay for primary Protection, Master Trip relay (Numerical) and Trip Circuit Supervision relay shall be provided.

2.1 General requirements of protection

- a) The price of the bid shall include whether explicitly mentioned or not, all the elements necessary to coordinate and assure the correct functioning of the protection, high reliability, selectivity, very short fault clearance time, and precisely dimensioned to the protected objects these tender specifications and scope of work.
- b) Modern relays employing state of the art technology & proven numerical design shall be offered by the bidder. They shall be of standard construction and supplied by an experienced and reliable manufacturer indicated in the list of approved vendors. The relays shall be designed for use with modern digital telecommunication system conforming to ITU-T recommendations and fibre optic medium.
- c) The type of relays/ devices, which are implemented to perform a particular function, shall be the same for all feeders in each system voltage level within the contract in question.
- d) Combination of two or more types of relays in a single unit is not normally acceptable since any fault or component failure may lead to loss of both or all functions respectively. However, when a modern integrated Numerical Multifunction Combined Protection equipment is offered, 100% redundancy shall be provided against the contingencies which lead to the loss of whole protection system.
- e) In addition to all components, the contractor shall supply the necessary documents and calculations of settings to guarantee the correct functioning of the protection equipment without exceeding the safe limits of the system operation or the equipment condition. Before the production of the current transformer commences, the Contractor shall submit for approval a verifiable calculation based on the design short circuit level of the substation, 18 kA at 11 kV, 25 kA at 33 kV and a network time constant not lower than 80 msec. to demonstrate that the offered protection, will be stable for faults outside the zone, will trip on the range of required tripping time and that the protection has sufficient sensitivity to work together with the offered CTs.

2.2 Features of Numerical Relays

- a) The connection from the relays to the communication port shall be with RS485. The bidder shall indicate the maximum permissible distance and type of cable for this type of connection. Bidder shall provide two ports for the same.
- b) An additional electrical or optical port shall be provided for the relays, to directly connect the signal to auxiliary channel of OLTE (optical line terminal equipment) bypassing the multiplexer or for redundancy purpose.
- c) The relays shall have communication port for remote monitoring, programming and control. Bidder shall indicate the type of protocol for this connectivity.
- d) It shall be possible to programme and set the relays locally as well as from remote end. It shall also be suitable for serial interfaces and software shall be provided to achieve this function through personal computer (PC). This shall have facility for both hand- held programmable device as well as PC based unit with necessary software.
- e) The sampling frequency for analog signals shall be minimum 2 kHz. Filtering and measuring techniques shall be used to ensure correct performance during all operating and transient conditions.
- f) The output and input sections shall be electrically isolated.
- g) Under 'alarm' conditions of outputs, programmable options shall be available to set the output to trip /inactive/ none/ previous state condition.
- h) The relays shall be provided with fault disturbance recorder event recorder, which can store 500 time tap events, and fault recorder with date and time stamping.
- i) The relay shall have remote communication facility. The interface shall ensure high dependability for genuine tripping signals and high security against spurious trip signals necessary in protection applications even if communication channel is disturbed.
- j) Bidder shall advise the Employer on the details of error performance characteristic and protocols used to ensure error free operation.
- k) Additional potential free contacts for all the Relay output i.e. trip as well as alarm signals shall be provided for connection to SCADA in the future.
- l) The modules shall have transmit and receive counters for each command such that the counter is incremented by actual output command. This shall help in analysis of problems. The counter information shall be in a non-volatile memory. Resetting the counter shall be possible only with authorized access.
- m) The relay shall have continuous automatic self-monitoring and alarming facilities. The above feature shall not affect the relay availability i.e. when an actual fault occurs in the system during the checking cycle, the above cycle shall

be immediately interrupted and the relay shall check and respond to the system fault. The system shall have the following visual indications for supervision of each command channel.

Input activated at transmit end, Command transmitted and received, Equipment in local and remote loop test, Test pass, Test fail, General alarm, and Equipment in synchronism.

- n) Each protection channel shall run an automatic loop test at regular intervals to monitor operational readiness. An unsuccessful test shall signal the alarm and block the command output. Also, if the system monitor detects any fault in the transmission, the protection command shall be blocked and alarm signaled.
 - o) Suitable event logs memory and down loading facility shall be available.
- 2.3 Miniature circuit breakers (MCBs) shall be used in VT secondary circuits, they shall have 2 NO and 2 NC auxiliary contacts for blocking trip circuits of voltage dependent protection and annunciation. Where high-speed protection is involved, the speed of operation of MCB shall be less than 5 milli seconds.
 - 2.4 The DC distribution system which feeds the protection shall be proper so that, the rating of the up-stream MCBs shall be chosen higher than that for the down- stream ones and the coordination between the up-stream MCBs with the down-stream ones shall exist. DC supply to trip coils shall be separately fused in case of single DC supply. Two independent feeders from the independent batteries shall be provided. An auto-changeover facility shall be provided so that in case of failure of one power source, other shall cut in automatically.
 - 2.5 Both positive and negative of the auxiliary voltage shall be switched when trip or close operation is executed in the substation switchgear.
 - 2.6 The external protection circuits shall use the standard available substation battery voltages. The voltage of the protection DC/DC converters shall never be used for external protection circuitry.
 - 2.7 The new protection system shall be completely wired, tested and inspected at the factory. The only work to be performed at site shall be the connection to external devices, the commissioning procedure and site tests.
 - 2.8 The continuity of all tripping circuits shall be continuously supervised for both close and open breaker status. The failure of any component of the supervision shall lead to trip the breaker. The lock out relays shall also be supervised.
 - 2.9 No time delay for the tripping contacts will be acceptable. Where a master trip relay, lock-out relay or any auxiliary relay is utilized, it shall have a maximum tripping time equal to or less than 10 ms. To avoid the additional time delay of the above relay on the total tripping time of the main protection, an arrangement shall be made so that the main protection shall perform the circuit breaker tripping along with energizing the lock-out relay in a parallel circuit arrangement.

- 2.10 The tripping of the back-up protection of each feeder shall be relayed by different control cables and as far as applicable, through different routes.
- 2.11 All relays shall have clear identification on the associated panel by well-written inscription plates. Where indications are provided by flag relays or LEDs, these shall also be specifically identified by permanently fixed inscription adjacent to them.
- 2.12 The supervision relays shall indicate an alarm and also a visual indication in the case of trip operation of the relay, DC supply failure, DC/DC converter failure, interruption in the trip circuit wiring and all alarm signals of the relay.
- 2.13 The tripping contacts of the protection relays shall reset automatically if no further fault conditions are present, whereas the signaling and blocking close order of the circuit breaker remains until the operator resets the relay manually.
- 2.14 Each indicator, whether of the electrical or mechanical type shall be capable of being easily reset by hand without special tools, opening the relay cover, bridging of some back/internal terminals or drawing-out the relay.
- 2.15 Before starting with the wiring diagrams, the contractor shall supply block diagrams in one drawing for each type of feeder and protection. These drawings shall include information concerning control circuits, tripping scheme, interlocking scheme, secondary circuits of voltage and current transformers, DC power supply, supervisory alarms and tele-protection circuits. These block diagrams shall be updated during the factory testing, erection and commissioning phases.
- 2.16 The contractor shall supply the setting data sheets of the supplied protection equipment showing the coordination with the rest of the network one-month before commissioning.

2.17 SPECIFIC DESCRIPTION OF PROTECTION

Transformer differential protection for 5 MVA, 33/11 kV transformer .

- a) This protection shall trip for all the phase and earth faults inside the zone and shall have to be stable for all faults outside the zone limited by the current transformers. This protection shall have restrained inrush-proof feature, which shall never prevent operation for tripping in case if a real fault exists within the relay zone during energization of the power transformer.
- b) This protection shall be immune to the zero sequence current, which may circulate, during certain conditions through the neutral of only one side of the transformer. It shall be a modern phase segregated relay of low burden with absolute stability at switchgear designed short circuit current rating and tripping time of not more than 25 m.sec, at flow of one side current equal to twice the nominal current. The tripping contactor of the relay shall have sufficient number of contacts of suitable switching capacity to trip all the circuit breakers which are supposed to be tripped through this protection and initiate the lock-out relay.

- c) The setting of bias and basic setting must be adjustable in steps in order to cover the maximum mis-match between the HV and LV due to error of the CT's and range of regulation of the tap changer.
- d) This protection should be wired to enable the measurement of differential and stabilization current in service without any possibility of causing open circuits on the secondary side of the current transformers.
- e) It shall have a visible annunciator, which will be reset by push button and shall be located on the relay.
- f) Although the CT ratio and vector diagram correction for the input currents to be performed within the relay itself. External interposing current transformers is not required.
- g) The CT shall be of class PS or X.

Restricted Earth Fault Protection 5 MVA, 33/11 kV transformer.

- a) The restricted earth fault relay shall be operated from a completely separate core of line and neutral current transformers. The dedicated CTs shall be of class PS or X and have same magnetization characteristics with a knee emf value higher than the highest possible setting of the relay. Intermediate CTs for ratio correction are not acceptable. CT sizing shall be matched with requirements from the relay.
- b) For this protection, 1-phase high impedance relay will be provided and all the aspects regarding stability of the protection, dimensioning of current transformer, considering the peak short circuit current, etc. and all the auxiliary equipment such as non-linear VDR resistor for voltage limiting, filter for harmonics and DC component suppression and variable shunt resistor for sensitivity adjustment if required shall be considered for the tender. The total fault clearing time shall not exceed 20 m.sec. at $3I_N$.
- c) Tripping of this protection shall activate all the circuit breakers surrounding the power transformer and all the material such as surge-proof inter-tripping relays if necessary, cables, test terminals, erection work, etc. is part of the scope of this protection.
- d) The stability of this protection against out-zone faults shall be confirmed. A calculation to show the proper dimensioning of the relay upto the maximum short circuit of the switchgear shall be submitted.

Auto-synchronising relay (for 33 kV incoming feeders and 33 kV & 11 kV bus couplers)

- a) This relay not only monitors the pre-conditions for synchronising, but also activates on-line correction signals, if necessary, to satisfy the conditions for synchronising.

2.18 **Overcurrent/ Earth Fault Protection (for Transformer, Incoming and outgoing line feeders and Bus coupler)**

- a) This relay shall be of the electronic/numeric multi-characteristics type which has a flexible mode selection facility so that, it shall be possible to select a certain mode for the over current elements and a one for the earth fault element.
- b) Phase current range shall cover at least 50-300% of I_N in steps of not more than 10% while the earth current range shall cover at least 5-100% of I_N in steps of not more than 5%.
- c) The time setting range of the definite time mode shall not be less than 5 seconds in steps each of 0.1 second.
- d) The time multiplier setting for the inverse time-current characteristic modes shall have a range not less than 0.05- 1.6 in steps each < 0.05 .
- e) Overcurrent and earth fault relays shall have separate timers and operation indicators.
- f) The high set element shall have a range of 2 - 15 times the nominal current at least in steps of 1 I_N shall be of low transient overreach, with a tripping time of less than 25 ms and possible to be selected on "blocked" position. Reset time shall be not more than 50 ms for both elements.
- g) The relays, which shall be installed on the transformer neutral side, shall be from single-phase version, but they shall have the same characteristics as the phase ones. The transformer neutral earth fault relay shall trip both transformer breakers.

2.19 **Auxiliary Relay**

- a) Voltage operated relays with sufficient contacts to initiate tripping, alarm, annunciation and logging for various trip functions like Buchholz relay operation, high oil temperature, high winding temperature, pressure relief valve operation, etc. shall be provided. Each relay shall have four (4) pairs of self-reset contacts except for Buchholz and "PRD" trip, which shall have hand, reset contact. The relays shall have hand reset operation indicators.
- b) Voltage operated relays with sufficient contacts to initiate alarm and data logging for various alarm functions for transformers, etc. shall be provided. Each relay shall have four (4) normally open self-reset contacts. The auxiliary relay for Buchholz alarm shall be slugged to have delay on drop off at 100 ms. The relays shall have hand reset operation indicator.

2.20 **Specific protection requirements**

33 kV Incomer and outgoing feeders – 67(AC directional over current Relay), 50 (Instantaneous over current relay), 51 (Overload relay), 49 (Thermal overload relay), 37 (Undercurrent or Underpower Relay), 46 (Reverse phase / phase balance current relay), 67N (Neutral directional over current relay) 50N

(Neutral instantaneous over current relay), 51N (Neutral time over current relay), 32N (Wattmetric Zero-sequence directional relay), 59N (Neutral over voltage relay), 27 (Under voltage relay), 59 (Over voltage relay), 50 BF (Breaker failure), 86 (Locking-out relay), 25 (Synchronizing or Synchronism-Check Device).

Transformer Protection for 5 MVA, 33/11 kV transformer– 87 (Differential Protective Relay), 50 (Instantaneous over current relay), 51 (Overload relay), 49 (Thermal overload relay), 27 (Under voltage relay), 59 (Neutral over voltage relay), 81 (Frequency relay), 24 (Volts-per-hertz relay/ over fluxing), 64 (restricted earth fault protection)

Master trip relay – for all the breakers.

Trip Circuit Supervision – for all the breakers.

2.21 Tests

All routine tests shall be carried out on the assembled switchboard / panel during inspection at the manufacturer's works as per applicable standards. Test reports for bought out items shall be presented for review/acceptance during testing. The bidder shall submit type test reports during the detail engineering which is less than 5 years old. 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.

3. METER SPECIFICATIONS FOR THE 33 KV & 11 KV BREAKERS.

Multifunctional meter for functions as shown in the single line diagram/specifications shall be provided. It shall be 3 phase 4 wire with **RS 485** port and **optical port**. It shall be provided with separate 3 phase 4 wire type test blocks for the testing of meters without disturbing the CT and VT secondary connections. The accuracy of the meters shall be 0.5 or better and capable of displaying maximum demand (kW/kVA). The detail specifications of meter are as follows:

1. Applicable Standards

The bidder shall supply Fully Static Intelligent Energy Meter with GSM/GPRS support. The static meter shall be manufactured and tested in accordance with the latest edition of the following standards:

- a. IEC 60687: Alternating current static watt-hour meters for active energy (classes 0.2 S and 0.5 S)
- b. IEC 61036: Alternating current static watt-hour meters for active energy (classes 1 and 2)
- c. IEC 61268: Alternating current static var-hour meters for reactive energy (classes 2 and 3)
- d. IEC 61107: Data exchange for meter reading, tariff and load control direct local data exchange

2. SERVICE CONDITIONS AND INSTALLATION

The static meter (The meter) shall be dust-proof type and installed in a cabinet, and suitable for operation under the following conditions:

Altitude	: up to 2,400 m above sea level
Ambient air temperature	: from -10 up to 40 °C
Average Daily Ambient Air Temperature	: 25 °C
Relative humidity	: from 20% – 100%
Climatic condition	: Varied, from tropical to severe winters
Average Annual Rainfall (mm)	: 1390 mm

The overall climate condition is moderately warm, dusty and humid, conducive to rust and fungus growth.

3. General Features.

- a) Accuracy class shall be class 0.5 or better.
- b) Measurement mode shall be able to measure the power for 3 phase 4 wire and 3 phase 3 wire.
- c) CT range – 1/5 Amps.
- d) Data storage shall be through Flash RAM.
- e) Equipment Failure Alarms shall be provided.
- f) The meter shall be bidirectional for net metering.
- g) The meter shall have capability for programming from the remote to change the various parameters such as tariffs.
- h) The energy value shall be directly computed without having to put the multiplying factor.

4. MOUNTING PROVISION

The meter is to be mounted on the panels.

5. MECHANICAL REQUIREMENTS

- a. Maximum demand zero reset
The maximum demand zero reset shall be manually initiated via the sealable demand reset button.
The maximum demand shall be automatically reset at predefined date after self-reading.
- b. Terminal and terminal block
Terminals shall be of high-conductivity brass with nickel plated or tin plated and suitable for the sizes of insulated cables to suit the site requirements.
- c. Potential circuit (direct-connected type)
The connection point(s) of potential circuit, test link(s), shall be only made inside the meter cover.

d. Meter and Terminal cover

The meter shall have provision for sealing and anti-theft features. The terminal cover shall be suitable for incoming and outgoing cables.

e. Nameplate

The inscription on nameplate shall be marked in English according to the relevant standard, and marked with three (3) additional marks as follows:

- i. SUPPLIED BY:
- ii. BPC No.: (The number to be marked on the nameplate shall be given by BPC after the final of bid consideration.)
- iii. Barcode shall be the similar ones used by the billing and shall be given to the supplier.

6. REGISTER UNIT

The register unit shall be an all solid-state microprocessor based register with internal memory of programmable and reprogrammable type. The internal memory shall be non-volatile semi-conductor type.

The register display shall be at least 6-digit LCD display with three (3) decimal points for power and two (2) decimal points for energy (programmable). The dimension of LCD display and number on LCD display shall be as per IEC standard.

The register unit shall be able to process data in at least two (2) following programmable modes:

- (i) To display the real time data and check the status of the meter
- (ii) To store and display the billing data for at least 60 days and the same shall be retained in case of power failure.

The register unit shall have the following display operating modes:

- (i) Scroll mode
The selected display data such as kW, kVar etc. shall be continuous sequence to display each data automatically for a programmable display scroll time up to 15 seconds.
- (ii) Manual operating mode
The push button/switch on the panel shall be used to start the display sequence and to display the various stored data.

The register unit shall display at least the following real time data:

- (i) Current date/time
- (ii) Maximum kW demand rate (Max 4 rates)
- (iii) Maximum kVar demand rate (Max 4 rates)
- (iv) Cumulative kW demand rate (Max 4 rates)
- (v) Cumulative kVar demand rate (Max 4 rates)
- (vi) Total kWh
- (vii) kWh rate(Max 4 rates)
- (viii) Total kVarh
- (ix) kVarh rate (Max 4 rates)
- (x) Per phase voltage and current (Instantaneous)

- (xi) Per phase power factor or phase angle (Instantaneous)
- (xii) System kW, kVar, and kVA (Instantaneous)
- (xiii) System power factor or phase angle (Instantaneous)

The display sequence and identified code can be independently specified by the user (programmable). The identified code shall be at least three (3) digits.

The display shall have symbols for indicating the operation of the meter, and also both import and export direction of measured active and reactive energy.

The display shall be able to indicate a unit of measure and the symbol of Electricity Rates.

7. FUNCTION FOR CHECKING

The meter shall be able to indicate defects, by displaying on LCD display, as follows:

- a) In case the meter is damaged or has internal defects (e.g. clock fail, memory fail, etc.).
- b) In case the meter measures in reverse direction, or energy flows in reverse direction.
- c) In case the voltage at any phase is lost or under the setting value.
- d) In case of low battery

8. REAL TIME CLOCK AND CALENDAR

The meter shall have an internal real time clock and/or a crystal-controlled time clock, supplied from the Lithium back-up battery in case of power supply failure, for providing calendar functions (i.e. the time of day, date, weekday, weekend, holiday, year). The Lithium back-up battery shall be socket type.

9. POWER SUPPLY

The auxiliary power supply for the meter shall be derived from PT & CT.

10. LOAD PROFILE FUNCTION

The meter shall be able to record load profile data of no less than two (2) channels, kW and kVar demand, every 15 minutes for at least 40 days in each channel. Load profile data shall not be effected when the power is lost.

11. SECURITY SYSTEM

The meter shall have a sophisticated security system to prevent fraudulent interference i.e. changing the tariff data or changing the meter reading.

The meter shall have at least three (3) following groups of accessible password:

- i. Group 1: Password for administrators to write the software and set the system of the meter.
- ii. Group 2: Password for programmers to program the operating functions of the meter

- iii. Group 3: Password for readers to read the stored data, including to correct the time of the meter

12. COMMUNICATION SYSTEM

Each meter shall have at least two (2) following communication systems:

- i. Optical port, easily accessed through the front of the meter cover, for data retrieval and program of all major operating characteristics of the meter.
- ii. RS485 for connecting with modem.

13. CT Ratios

Meters should have dual CT ratio of 1/5 Amps. The change in the CT ratio can be made only through a software and password authentications.

14. Tests and test reports

The meter shall pass the manufacturer's standard routine tests. The following type tests shall be in accordance with the latest relevant IEC or ANSI:

- Test of insulation properties:
 - impulse voltage test
 - A.C. voltage test
- Influence of short-time over currents
- Influence of heating:
 - windings, if any
 - external surface
- Electromagnetic compatibility (E.M.C.):
 - radio interference measurement
 - fast transient/burst test
 - immunity to electromagnetic HF field test
 - immunity to electrostatic discharge test
- Others according to manufacturer's standard
- Heating (permissible temperature rise) of:
 - windings, if any, in K
 - external surface in K

The acceptance inspection shall be according to the latest relevant IEC or ANSI

4.0 Power and Control Cables

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

4.2 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 cables: 900 mm & for LV cables: 750 mm
 - 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 mm². Copper for all control cables, DC cables, and lighting wires.
- d) Insulation : XLPE (for HV/MV/LV, control cables and lighting wires)
- e) Outer Sheath : Extruded FRLS (for Control cables)
- f) Inner sheath : Extruded
- g) Multi core cables : Control cables shall be as per the BOQ and site requirements. All CT cables shall be 4C x 2.5 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.
- h) Armouring : Galvanised steel (Aluminium for single core)

4.3 MV/LV Cables

- a) 33 and 11 kV cables - 33 kV, 3 C x 300/185 sq.mm and 11 kV, 3C x 300 sq.mm. XLPE, Aluminium, earthed grade cable.(As per the BOQ).
- b) LV cables - 1.1 kV grade, 4 C, XLPE, Aluminium, earthed grade cable, Rating as per BOQ and if the same is not adequate it shall be decided during detail engineering.
- c) 11 kV Indoor Switchgear to 11 kV Take-off Structure - 11 kV, 3CX300 XLPE, Aluminium, earthed grade cable
- d) 33 kV Indoor Switchgear to 33 / 11 kV transformer terminal box - 33 kV, 3C(As per BoQ) x 300/185 sq. mm., XLPE, aluminium, earthed grade
- e) 33 kV Indoor Switchgear to 33 kV Take-off Structure - 33 kV 3C(As per BoQ) x 185/300 sq. mm, XLPE, aluminium, earthed grade

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

- 4.4 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/cable termination only after finalizing the cable schedule and not based on the BOQ in order to minimize the stores and spares.**

- 4.5 LT and DC cables shall be sized taking into consideration maximum voltage drop of 2%.
- 4.6 33 and 11 kV cables shall be supplied in steel drums. The contractor may take back the steel drum after completion of the works.
- 4.7 Tests
- 4.7.1 Cables shall be subjected to routine tests as per the applicable standards.
- 4.8 **Cable Trays and Carrier System**
- 4.8.1 Cable Trays supports
- Cable tray supports such as angles, channel, etc shall be of MS type.
- 4.8.2 Cable Trays
- 4.8.2.1 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.
- 4.8.2.2 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.
- 4.9 **Power and Control Cable Terminations**
- 4.9.1 Terminals for power connections shall be complete with adequate phase segregating insulating barriers, shrouds and suitable crimping type of lugs for terminating the cables.
- 4.9.2 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.
- 4.9.3 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.
- 4.9.4 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.

5 - MISCELLANEOUS ITEMS

5.1 Lighting System

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

5.1.2 General Requirements

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

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

5.1.2.3 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.

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

5.1.3 Lighting Panels

5.1.3.1 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.

5.1.3.2 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.

5.1.3.3 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.

5.1.3.4 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.

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

5.1.3.5 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.

5.1.4 Lighting fixtures and its accessories

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

5.1.4.2 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.

5.1.4.3 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 shall 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.

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

5.1.4.5 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.

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

5.1.5 Illumination levels

5.1.5.1 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

5.1.5.2 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.

5.1.5.3 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
- 5.1.5.4 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.
- 5.1.6 Receptacles with switches
- 5.1.6.1 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 industrial 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.
- 5.1.6.2 Following 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
- 5.1.7 Switches
- 5.1.7.1 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.
- 5.1.7.2 Scope of Lighting system for various areas:
 - a) Indoor lighting system for the respective rooms and outdoor flood lighting for roads, transformer and entrance.
- 5.1.8 Tests
- 5.1.8.1 Lighting panels, fixtures, receptacles and other accessories shall be subjected to routine and acceptance tests as per the applicable standards.
- 5.2 Earthing Protection System
- 5.2.1 Applicable Standards : ANSI/IEEE Std. 80 & 142
IEC 61024, IS:2303,
IS:3043, IS:2309

5.2.2 Requirements

5.2.2.1 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.

5.3 **33/ 11 kV Structure**

5.3.1 33 and 11 kV Incoming and outgoings from the 33/11 kV switchgear shall be by 33/11 kV grade earthed cables. The cables shall be terminated on a take-off structure.

5.4 **Insulators and Hardware**

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

5.4.2 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 mm² 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	25 mm/kV	25 mm/kV
Puncture voltage	kV	180	105
Minimum power frequency flashover voltage	kV	140	110
dry	kV	95	70
wet	kV	95	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.

5.4.3 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	25 mm/kV
Puncture voltage	kV	105
		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 mm² or 100 mm² or 50 mm², 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.

5.4.4 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.

5.6 Tests

- 5.6.1 Certificates of type tests carried out on arresters, insulators and hardware of similar type shall be furnished during detail engineering.
- 5.6.2 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.

5.7 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.

5.8 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 5MVA transformer.

5.9 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 VI - C – 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 sand 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 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 faces.

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 VI - D – Installation, Testing and Commissioning

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 mm² 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 capping 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 OCTC
- 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 VI - E – Drawings, Test Certificates, O&M 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. A4 size drawings will not be acceptable. 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 : Contracts Management Section, Construction Division, Construction and Procurement Department, Bhutan Power Corporation Limited.
- b) Project Title : Up-gradation of 33/11 kV substation.
- c) Project No. : BPC/DS/DCD/ED/C-12

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
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Single line diagrams :	<ul style="list-style-type: none"> 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. iv. Reference drawings.
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General :	<ul style="list-style-type: none"> 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. iii. Reference drawings
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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.
- b) 33/ 11 kV distribution and station transformers :
 - i. General arrangement drawing showing plan, front and side elevations and all accessories and fittings with detailed Bill of Material. Detailed dimensions, net and shipping weights, crane lift for untanking, size of lifting lugs and eyes, clearances between HV, MV, LV terminals and to ground, identification for fittings and accessories, centre lines in both the directions, details of anti-earthquake clamping device, details of HV, MV, LV bushings, MV, LV, cable box, foundation and transport details, detailed manufacturer's catalogues/literature of accessories actually being supplied.
 - ii. Rating and terminal marking plate showing polarity, vector group and other details.
 - iii. Valve schedule plate
 - iv. GA drawing of OCTC, marshalling box, etc.
 - v. Cooler control schemes
 - vi. Control and wiring diagram of OCTC, marshalling box, etc.
 - vii. Inter-connection schedule.
- d) Outdoor substation equipment/ systems:
 - i. Detailed dimensioned plan and sections (for each equipment and for the substation) indicating therein salient features of equipment such as fault withstand capacity, overall dimensions, centre of gravity, weight, etc., detailed bill of material with makes for equipment, mounting details of equipment with structure identification of clamps and connectors etc.

- ii. Earthing and lightning protection drawings, equipment layout, cabling, lighting and earthing systems drawings for outdoor areas.
 - iii. Detailed drawings for the substation structures, equipment and clamps/connectors.
 - iv. Foundation layout drawings.
 - v. Control and protection schematic diagrams.
 - vi. Detailed one line diagrams.
 - viii. Cable schedules and interconnection wiring diagrams.
 - ix. Typical installation detailed drawings.
 - x. Manufacturer's catalogues/literature etc. of equipment being supplied.
- e) 11 kV indoor switchgear:
- 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 15 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, OCTC, 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 VI -F - 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:

$$\text{SEVERITY} = \frac{\text{LOST MANDAYS DUE TO LOSS-TIME INJURIES} \times 1000000}{\text{MANHOURS WORKED}}$$

$$\text{FREQUENCY} = \frac{\text{NUMBER OF LOST TIME INJURY} \times 1000000}{\text{MANHOURS WORKED}}$$

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 SAFEGUARDING**

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 liaising 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 shall 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 shall 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 VI - G – List of Approved makes

1.1.0 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	Voltamps Transformers Ltd.	Vadodara
1.1.8	Siemens Ltd.	Mumbai
1.1.9	Kanohar Transformers	Meerut

1. 2.0 Distribution Transformer

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
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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	Rajasthan
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 Industries 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	Kolkata
8.3	Continental Engineering	Lucknow
8.4	Control and Protection	Kolkata
8.5	L&T Ltd.	Mumbai
8.6	Vikas	Lucknow
8.7	Sarvana	Bangalore

9.0 Substation Structures

9.1	RPG Transmission	Delhi
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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	Kolkata
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	Mumbai
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	Kolkata
16.6	Electro Service (India)	Kolkata
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.

Section VI - H – Bid Purpose Drawings