

**TECHNICAL SPECIFICATION  
FOR  
ELECTRICAL WORKS**

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## SECTION – E – 1

### SPECIFICATION FOR MATERIALS AND EQUIPMENT

#### GENERAL:

This Technical Specification refers to the Street Lighting Electrical Services; to be supplied and installed in Karachi based Projects.

The Contract shall include the supply of equipments and materials (including all load and lift), installation, completion, testing and commissioning of the individual components of electrical system and finally the complete installation of electrical system in accordance with the conditions of contract, specifications, drawings, bill of quantities and as per applicable International Codes & Standards.

These Specifications covers the following scope of works:

#### **SCOPE OF WORK:**

- Provision of 11000/400 V supply.
- Provision of MV Cable.
- Provision of 11000V / 400 V Transformers.
- Provision of L.V Lighting Control Panel (LCP)
- Provision of L.V Cable
- Provision of LED Street lighting
- Provision of Road Lighting Poles
- Provision of Diesel Generator
- Provision of Earthing System
- The supply, delivery, offloading, installation, testing and commissioning of the above mentioned services.

#### **General Electrical Requirements**

The Contractor shall carry out all the work in accordance with the specification and in conformity with the Electricity Act and Rules as adopted in PAKISTAN and the latest edition of the British Standard Specifications and Wiring Rules of the Institute of Electrical Engineers (London) hereinafter referred to as the (I.E.E. Wiring Rules). Where these specifications differ from the rules stated, these specifications shall be followed:

The entire electrical installation/work shall be carried out by the licensed contractor, authorized to undertake such work under the provisions of Electricity Act and The Electricity Rules as adopted and modified up to date by the Government of PAKISTAN. The licensed contractor must be registered with PAKISTAN Engineering Council (PEC).

Any special requirements of the Electrical Inspector shall be complied with by the contractor, and all works shall be to the entire satisfaction of the Government Inspector/Engineer.

The Contractor shall be responsible for completing all formalities and submitting the test certificates as per prevailing rules and regulations and shall have the installation passed by the Government Electric Inspector of that region.

If during preparation of the bid, the Contractor finds any error /discrepancies /omission / ambiguity/ uncertainty that need clarification, the same shall be referred to the consultant.

- a. Any installation not complying with the specification shall be corrected/ replaced
- b. It shall be the responsibility of the Contractor to protect equipment and materials (installed or stored) from damage till final taking over by the Employer.
- c. The materials shall be purchased from approved contractor.
- d. The Contractor shall produce comprehensive documentation of individual testing, calibration and installation together with an overall record of the state of completion to the client as per tender conditions.
- e. It will be the responsibility of the Contractor to coordinate between other agencies and client shall accommodate other utilities/services.
- f. The work shall be carried out in accordance with the B.S.S, I.E.C and I.E.E. Rules and Regulations as adopted in PAKISTAN, to satisfy the requirements of the client.
- g. The Contractor shall ensure at his own cost the permanent availability of this specification, drawings and Contract agreement on site.
- h. The quantities set out in the bill of quantities are the estimated quantities and they shall not be taken as actual and correct quantities of work to be executed by the Contractor. The Contractor shall carry out work as per approved drawings.

### **ELECTRICAL EQUIPMENT AND MATERIALS**

All materials, equipment, accessories, fixtures & fittings shall be new and of latest available model and in accordance with specifications as mentioned below. A manufacturer's written guarantee, valid for at least 18 months from date of delivery or 12 months from the date of commissioning, shall be supplied for all equipment. Samples and detailed manufacturer's shop drawings (including dimensional plans, elevations, sections, line and wiring diagrams, foundation details, component characteristics and data. Etc) shall be approved by the Employer/Engineer/Consultant

before purchase or fabrication. Routine tests at the manufacturer's works shall be witnessed by the Employer/Engineer/Consultant, and test certificates (in duplicate) shall be provided to him. Three copies of the manufacturer's operating instructions and technical literature, bound into a Maintenance Manual, along with the "as-built" drawings, shall be supplied free of cost by the Contractor.

All workmanship shall be first class and undertaken by licensed workmen, skilled in the particular type of craft.

The Contractor shall write "Number of Pole" on all Road Light poles as specified in drawings and provide "Shock Charts" wherever required to comply with the requirements of Electricity Rules at no extra cost to the Employer/Engineer/Consultant.

The cost of all civil works associated with any item of electrical works, shall be included in the bid price for electrical works. No separate payment for such works will be made.

- a. The Contractor shall supply all materials, tools, plants, equipment, scaffolding, hardware, supports and fixing as necessary to complete the installation satisfactorily.
- b. All material and equipment supplied by the Contractor shall be new and in all respects conform to the high standards of Engineering design, workmanship, performance, quality and function as here in specified and fully meet the quality level and requirements of the specifications and shall be purchased from approved sources.
- c. The Contractor shall be solely responsible for ensuring proper functional requirements of various equipment.
- d. Where any materials in the Contractor's supply are specified on the drawings or in Bill of Quantities, the same shall form part of the specification.
- e. Where equipment, materials or articles are referred to in the specifications as "Equal to" any particular standard, the choice and approval of the same shall rest with the client
- f. Approval of the Contractor's supplied equipment / installation works shall not relieve the Contractor of any of his obligations or liabilities under the Contract, except insofar as provided under the conditions of the Contract.
- g. The Contractor shall supply all small installation and consumable materials without any extra cost such as nuts, bolts, washers, shims, angles, levelling materials, insulation tape, PVC strap-on or heat shrinkable type cable tags, cable ties, bushes, sealing compound, AVO meter, electrical testing and measuring instruments, etc., and all such other material not listed in BOQ, required for complete installation as intended by the specification and scope of works.

## **CODES AND STANDARDS**

- a. The latest published rules of the National Electrical Code (NEC), so far as applicable to the work, British Standards (BS), International Electro Technical Commission (IEC), Institute of Electrical Engineers (IEE) and National Standards. Rules and Regulations of Provincial/Local Authorities shall be considered included as part of these specifications and all their requirements shall be fully met.
- b. The entire installation shall be free from improper grounds, open and short circuit faults. Tests shall be made in accordance with Section "E" of IEE Regulations for the electrical equipment of building 17th Edition. Each panel shall be tested with mains connected to the riser, branches connected, switches off, all fixtures in place and permanently connected, and lamps removed or omitted, sockets and wall switches closed. Each individual power line shall be tested with the power equipment connected for proper and intended operation. In no case shall the insulation resistance be less than that allowed by the Regulations for electrical equipment of buildings and manufacturer's recommendations based on British standards. Failure shall be corrected in a manner satisfactory to the client.
- c. It shall be the responsibility of the Contractor to test all systems of the entire electrical installation as well as those installations where sequence in operation is required. The electrical contractor shall test for proper sequence and the consultant shall leave the entire electrical installation in satisfactory working condition.
- d. The Contractor shall guarantee that the electrical systems including all components and accessories used therein are free of all grounds, shorts and open circuit faults, defective workmanship and materials.

## **ALTERATIONS**

The location of various items indicated on the drawings are presumed to be approximately correct, but it is to be understood, however, that the small scale drawings are necessarily diagrammatic and that such locations as are shown, are subject to slight revision, the work is in progress or equipment is installed, which may be necessary to accommodate local construction condition or interference with other services. No major changes shall be made without the approval in writing of the client. On obtaining client approval, the position of any point may be altered without extra charge being made. The location of poles/LCP shown in the systematic plans should be considered as approximately correct.

## **PROTECTION**

The Contractor shall effectively protect the work from damage during and as may be necessary, after installation and he shall likewise protect adjoining work of other trades from damage resulting from installation of electrical work.

## **OPERATION AND MAINTENANCE MANUALS**

The contractor shall submit the operation & maintenance manual for all equipments, which were supplied by vendors. The completion of document and preparing a comprehensive manual shall be the responsibility of contractor.

## **DRAWING AND DATA TO BE FURNISHED BY THE CONTRACTOR**

The Tender Drawings are schematic and are intended to enable the Contractor to prepare his estimate and submit a tender.

Checking of the Contractor's Shop Drawing by the Engineer, shall not relieve the Contractor of his responsibility for compliance with the design intent, coordination or with any other obligations and requirements under the contract.

The Contractor shall allow in his Tender for providing:

- a) **Shop Drawings:** The location, routing and installation heights of the equipment etc., which are given on the detailed approved drawings, are approximate. These drawings depict only the position of various fixtures and outlets. All the detailed planning for electrical system including conduit routes etc. shall be carried out well in advance of the actual execution of work, by the Contractor to the satisfaction of the client. For this purpose the Contractor shall prepare Two copies of shop drawing for preliminary checking by Consultant. Four copies of finally approved shop drawing for onward transmission to Clients etc.
  
- b) **As-built Drawings:** Two copies of As-built drawing for preliminary checking by Consultant. Four copies of finally approved As-built drawing and reproducible drawing for on ward transmission to Clients etc.

All drawings prepared by suppliers, manufacturers and/or Contractor shall be endorsed with the Contractor's own name title block and drawing number and the Contractor shall take full responsibility for such drawings in accordance with his obligations under the contract.

Sample and manufacturer's detailed shop drawing (including dimensional plans, elevations, section, single line and wiring diagrams, foundation details, component characteristics and data etc.) shall be got approved by the Contractor from the Employer/Engineer/Consultant before purchase or fabrication.

## **EQUIPMENT PROTECTION**

Unless otherwise noted, all equipment supplied shall conform, as a minimum, to the protection classes IP66.

With the exception of material specified to be hot-dip galvanized (after fabrication), or otherwise specified, all metal work (steel conduit and accessories, outlet and pull boxes, trunking, straps, brackets, hangers, frames etc) shall be given a protective treatment consisting of degreasing, derusting, two coats of zinc-chromate/red-lead primer, and resin-bonded powder coat finish (70µm thickness, 150µm on edge) during manufacture. After installation on site, any damage metal work shall be given another coat of paint. Painting of steel conduits shall be to BS 1710 for colour coding purposes.

## **TESTING & COMMISSIONING**

Stage wise testing of the installation shall be carried out at site before/after commissioning of equipment and shall include the following as a minimum:

- a) Polarity test for switches, MCB's, MCCB's and fuses.
- b) Earthing resistance tests and circuit earth loop resistance tests.
- c) Voltage withstand test on switchgear and cables by 1000 Volts Megger.
- d) Tests as specified for special electrical systems.
- e) The control systems shall be tested for correct operation by trial run and simulation of all operating and fault conditions.
- f) Operation, testing and commissioning of the entire installation.
- g) Copies of final test reports and values shall be provided to the Consultant/Employer/Engineer in triplicate

## **Factory Tests**

### ***General***

All type and routine tests on switchgear/LCP and all other equipment shall be performed at the manufacturer's work in the presence of the Engineer or his representative. Type tests may be waived off in case test certificates (certified by an approved standard laboratory of international repute) are provided by the contractor and approved by the Engineer.

The contractor shall inform the Engineer about the date and time of test of each equipment at least two weeks in advance. The witnessing of test by the Engineer or his representative shall not absolve the contractor from his responsibility for the proper functioning of the equipment and for furnishing the guarantees. All test result shall be supplied in triplicate.

### **Insulation Resistance Test**

Insulation resistance test shall be made on all electrical equipment by using a meggar of 1000 volts.

The insulation resistance values of cables, switchgear, etc. shall be as per BSS, IEC and Pakistan Electricity Rules.

### **Field Tests**

#### **a. General**

Upon completion of the Installation, the contractor shall perform field tests on all equipment, materials and systems. All tests shall be conducted in the presence of the Engineer for the purpose of demonstrating equipment operation or system compliance with Specifications. The contractor shall submit, for Engineer's approval, complete details of tests to be performed describing the procedure, test observations and expected results.

The contractor shall furnish all tools, instruments, test equipment, materials etc. and all qualified personnel required for the testing, setting and adjustment of all electrical equipment and material including putting the same into operation.

All tests shall be made with proper regard for the protection of the personnel and equipment and the contractor shall be responsible for adequate protection of all personnel and equipment during such tests.

The contractor shall record all test values of the tests made by him on all equipment. Three (3) copies of all test data and results certified by the Engineer shall be given to the Engineer for record purposes. These shall also include details of testing method, testing equipment, diagrams etc.

#### **b. Insulation Resistance Test**

Before making connections at the ends of each cable run or joint between cables, the insulation resistance test of each cable section shall be made. Each conductor of a multicore cable shall be tested individually with each of the other conductor of the group and also with earth. If insulation resistance test readings are found to be less than the specified minimum in any conductor, the entire cables shall be tested and joint made only after the tests have been made satisfactorily. Finally the completed cable length including the joints shall be tested.

All switchgear shall be given an insulation resistance test after installation, but before any wiring is connected. Insulation tests shall be made between open contacts of circuit breakers, switches and between each phase and earth.

If the insulation resistance of the circuit under test is less than the specified value, the cause of the low reading shall be determined and removed. Corrective measures shall include dry-out procedure by means of heaters, if equipment is found to contain moisture. Where corrective measures are carried out, the insulation resistance readings shall be taken after the correction has been made and repeated twice at 12 hours interval. The maximum range for each reading in the three successive tests shall not exceed 20% of the average value. After all tests have been carried out, the equipment shall be reconnected as required.

### **c. Earth Resistance Test**

Earth resistance test shall be made by the contractor on the earthing system, disconnecting and reconnecting each earth connection.

If it is indicated that soil treatment or other corrective measures are required to lower the ground resistance values, the Engineer will determine the extent of such corrective measures.

The electrical resistance of the ECC together with the resistance of the earthing leads measured from the connection with earth electrode to any other position in the complete installation shall not exceed **ONE** ohm.

Earth resistance test shall be performed as per electrical inspector's requirements. Where more than one earth electrodes are installed, the earth resistance test of each electrode shall be measured by means of resistance bridge instrument.

### **d. Switchgear/LCP test**

Each circuit breaker shall be operated electrically and mechanically. All interlocks and control circuits shall be checked for proper connections in accordance with the wiring diagrams furnished by the manufacturer.

The contractor shall properly identify the phases of all switchgear and cables for connections to give proper phase sequence.

Trip circuits shall be checked for correct operation and rating of equipment served. The correct size and function of fuses disconnect switches, number of interlocks, indicating lights, alarms and remote control devices shall be in accordance with approved manufacturer drawings. Name plates shall be checked for proper designation of equipment served.

## **1. EXTRA WORK**

- a. Written approval from the Consultant shall be obtained before any extra/additional work is carried out.
- b. Rate analysis of extra item is to be prepared and enclosed (on the basis of cost plus twenty percent overheads, profit, etc) with the bills.

## SECTION – E – 2

### 15 KV, MEDIUM VOLTAGE CABLE

#### 1.0 SCOPE

The work under this section consists of supplying, installing, testing and commissioning of all material and services of Medium Voltage cable and accessories as specified herein or as stated on the drawings and in the Bill of Quantities.

The Contractor shall discuss the electrical layout with the Engineer and co-ordinate at site with other services for exact route, location and position of the MV cables.

The Medium Voltage cable with accessories shall also comply with the General Specifications for Electrical Works Section- 1 and with other relevant provisions of the Tender Documents.

#### 2.1 GENERAL

The 15kV MV cable shall be three core, Aluminium conductor, cross-linked polyethylene (XLPE) insulated, shielded, armoured as per requirements and overall sheathed. It shall be suitable for indoor and outdoor use in the transmission and distribution of electrical energy.

The cables shall be capable of operating continuously at a conductor temperature of not less than 90°C and shall be suitable for 8.7/15 kV, 50 Hz in three phase grounded system in accordance with IEC 60502.

The cable shall be treated for vermin proofing and be protected against rodents during storage, laying.

#### 2.2 APPLICABLE STANDARD / CODES

The following standards and codes shall be applicable for the materials within the scope of this Section:

**IEC 60502** - Extruded solid electric insulated power cable for rated voltage from 1 kV to 30 kV.

**IEC 60540** - Test methods for insulation and sheaths of electric cables and cords.

**IEC 60228** - For resistance of conductors.

**IEC 60332-1** -For flame retardant test.

**IEC 60332-3** - For fire resistant test on fire resistant cables.

**IEC 60227** - For core identification by colours.

## **2.3 MATERIAL**

### **2.3.1 15kV Cable**

The cable shall meet the following specifications:

<b>Nominal/System Voltage</b>	-	<b>11 kV</b>
<b>Frequency</b>	-	<b>50 Hz</b>
<b>Conductor Size</b>	-	<b>Sq.mm. As given in BOQ,</b>
<b>Number of Cores</b>	-	<b>3</b>
<b>Rated Voltage</b>	-	<b>8.7 / 15kV</b>
<b>Continuous operating</b>		
<b>Temperature of conductor-</b>		<b>90 °C</b>
<b>Conductor material</b>	-	<b>Aluminium stranded</b>
<b>Insulation</b>	-	<b>Cross-linked polyethylene (XLPE)</b>
<b>Shielding</b>	-	<b>Aluminium tape</b>
<b>Jacket</b>	-	<b>PVC</b>
<b>Armouring</b>	-	<b>Galvanized steel wire</b>
<b>Over sheathing</b>	-	<b>Extruded PVC</b>
<b>Phase identification</b>	-	<b>Red, Yellow, Blue</b>

### **2.3.2 Conductor**

The conductors shall be of high conductivity electrolytic Aluminium, stranded in accordance with specified standard.

### **2.3.3 Insulation**

The insulation shall be cross-linked polyethylene extruded over the conductor. The insulation shall be laid to avoid any gap/air pockets between the conductor and insulation. The insulation colour red, yellow and blue for phase identification by providing tape.

The insulation shall be easy to strip from individual conductors and to separate for jointing/termination purposes.

### **2.3.4 Shielding**

Each core shall be shielded by a layer of semi-conducting material applied directly over the insulation. The semi-conducting insulation shall be covered by a bare copper tape applied with suitable overlapping.

Phase identification tape of red, yellow and blue colours shall be wrapped over the copper shield.

### **2.3.5 Assembly**

The three insulated conductors shall be assembled with PVC or any non-hydroscopic filler and bounded with tape. The tape binder shall then be covered with extruded PVC jacket. The PVC jacket shall be padded with a suitable material before application of armour.

### **2.3.6 Armour**

Armouring shall be provided with single layer of galvanized steel wire to provide cable protection and also act as a low resistance earth return path. The armouring shall be covered with binder tape. The armour shall be of appropriate size to carry the system fault current.

### **2.3.7 Over sheath**

The entire cable assembly shall be covered with a PVC jacket of thickness not less than 2.5 mm. The colour of the jacket shall be black.

Embossed marking on the over sheath at 3 meters intervals shall give the following information:

- **Name of Manufacturer**
- **Year of Manufacture**
- **Size of cable in sq.mm.**
- **Voltage grade**
- **Type of cable i.e. Al., XLPE/SWA/PVC**
- **Project/ Client name (if required)**

### **2.3.8 Factory Tests**

Physical and electrical acceptance tests in accordance with applicable standard shall be carried out at the manufacturer works in the presence of Engineer. Three copies of test reports will be furnished to the Engineer, which shall include brief description of tests, test records and results.

### **2.3.9 Termination Kits**

Cold shrink Termination kits for 15 kV cable shall be indoor/outdoor type as per requirement and recommended by cable manufacturer and as approved by Engineer. The termination kits shall be complete with all materials.

### **2.3.10 Cable Accessories**

All cable accessories shall be provided for the complete cabling system without any additional cost unless specifically mentioned in BOQ. These shall include but not limited to the items such as saddles, clamps, fixing channels, connectors, clips, lugs, tapes, solder identification tags, bushes, glands etc.

### **2.3.11 Cable Reels**

The cable shall be supplied in non-returnable, mechanically strong, rail/ road worthy, wooden or metallic cable drums, protected against weather. The cable drum should bear the markings for cable type, cable size, voltage grade, year of manufacture, name of manufacturer, direction of unreeling, and any other additional marking normally provided by the manufacturer. Cable ends on cable reels shall be protected by means of suitable seal.

### **2.3.12 Cable Markers**

Above ground cable markers made of Grade-25 reinforced concrete shall be erected at a maximum interval of 200 metres along the straight trench, at each bend and joint box for indicating the presence of underground cables. Where the trench changes its direction two number of markers shall be installed one in each direction to indicate the two directions of the trench. At the joint box, additionally a symbol shall be engraved just beneath the letters MV to indicate the presence of the joint box.

The cable markers shall be finished in grey paint. The letters and symbols for indication shall be engraved in concrete on both sides. Letters shall be MV for medium voltage or low voltage cable. The colour of the engraved letters and symbol shall be black. The dimensions of the markers shall be as shown on the drawing and shall be installed in the ground as shown.

## **2.4 INSTALLATION**

### **2.4.1 General**

All installation material, labour, tools and accessories for cable installation shall be furnished by the Contractor. The cable and accessories shall be installed as described in these Specifications, drawings and in accordance with manufacturer's instructions.

Necessary precautions for safety of cables shall be taken during the laying of cables to avoid scratches/ cuts to the cable surface. Pulling force on cable at all times shall remain well within the manufacturer's recommended limits.

The exact cut lengths for cable shall be confirmed by the Contractor by actual measurements at site prior to the commencement of manufacturing. The cable lengths where shown on the drawing are tentative and only for general guidance. The Contractor shall be solely responsible for furnishing correct lengths of cable to avoid joints in cable length except where necessary, after obtaining approval of the Engineer.

Prior to installation of jointing and termination kits, the cable lengths shall be checked and tested to ensure that the cables are in sound condition, and no damage has been done during handling and installation. After the MV cable and jointing/termination kits are installed, it shall again be tested prior to commissioning and in accordance with recommendations of standard to which the cable is manufactured. All protective pipes/ sleeves shall be plugged to attain the same after installation.

#### **2.4.2 Underground Cables**

The cables to be installed directly underground shall be laid in trenches in single tiers. Unless shown specifically on the drawing the depth of cable below finished ground level shall be 900 mm minimum measured from the top of the largest cable to the general ground level. The burial depth may be increased as required due to site conditions or when crossing other service pipes and roads. Burial depth less than 900mm and more than 1500mm shall require Engineer's approval.

When cables cross road, paved area, other services or other cables, they shall be laid in protective pipes of required size. All the protective pipe ends, after installation of cables, shall be plugged water tight by means of sealant as approved by the Engineer. A minimum clearance of 250mm vertically and 500mm horizontally shall be maintained between cables and other services.

The cable trench shall be excavated as per route and location shown on the drawing. Before laying of cables in the trench, the bed of the trench shall be levelled and filled with a 100mm thick layer of fine sand (1.3mm diameter maximum particles size). The sand layer shall be levelled and the cables placed thereon. The cables shall be covered with a layer of fine sand 100mm thick measured above the top of the largest cable. The cable protective tiles placed above the top of sand cover shall be of class-C cement concrete, minimum 50mm thick and 300mm square. The tiles or bricks shall be placed over the sand layer end to end to cover the entire length and breadth of the cable trench. After the concrete tiles/ bricks are placed, the remainder of the trench shall be backfilled with earth in layer 300mm thick. Each layer shall be thoroughly tamped and compacted.

A PVC warning tape shall be provided at 300 mm below normal ground level covering the entire length and breadth of the trench. The warning tape shall be yellow in colour with markings of danger and voltage of the cables printed in black.

Cable identification tags of water resistant material with indelible marking shall be fixed to cables with ties at a maximum of 20 metres interval along the cable length for identification of cable and circuit. The earth continuity conductor/counterpoise conductor shall be laid in the trench with the cable. The Contractor shall submit to the Engineer for approval, schedule of cable markers showing location of marker and instructions on each.

Sufficient slack shall be left in cables for which purpose the cut lengths of cables shall allow about 3% more in the measured lengths between terminations. At underground joint box, ample slack shall be left to prevent straining of cable joints due to settlement of the cable trench.

The cut lengths of cables wherever stated are only as a guide. The Contractor shall measure lengths between terminations of each circuit and if the discrepancy between measured lengths at site and where given on the drawing differ by more than 5%, the Contractor shall report to Engineer and act as directed. Cables, whether installed underground, or in cement concrete trenches, shall not be bent to a radius less than that recommended by the cable manufacturers.

### **2.4.3 Cable Marker**

The cable marker shall be installed on finally compacted trench at mentioned distances.

Above ground, cable markers shall be erected at a 200 metre interval along the straight trench, and at each bend and joint box for indication of presence of underground cable. For more than one metre wide trenches, cable markers shall be provided at both edges of the trench. The cable marker shall bear the necessary instructions indicated in approved colours.

The Contractor shall submit to the Engineer for approval, schedule of cable markers showing location of marker and instructions on each marker.

## SECTION – E – 3

### TRANSFORMER

#### 1.0 GENERAL

These specifications are produced in the form of recommendations for equipment and shall be used in the form of standard for the product. This specification is intended to assist in the procurement of the equipment for street lighting.

#### 1.1 SCOPE OF WORK.

The scope of this section of specification is to supply installation, testing and commissioning of Pole mounted Transformers. The Transformers shall be installed at locations shown on the drawings. For installation details the manufacturer's recommendations is to be followed.

#### 1.2 SPECIFICATIONS

The capacity of the Transformers shall be as shown on the drawings. The Transformers shall be oil- immersed type naturally cooled 3-phase outdoor type to BS 171 / IEC 60076 and as per K - Electric standard specifications complete in all respect.

**The Transformers shall meet the following specifications.**

- Type : ONAN
- Voltage ratio at no-load : 11000 / 415 volts.
- Frequency : 50 Hz
- Vector Group : DY 11
- ON load tap changer (HT) :  $\pm 2.5\%$ ,  $\pm 5\%$ ,  $\pm 7\%$
- HT connection : 11 KV Delta
- LT connection : 415 V with grounded star point.
- Neutral on LT side : Solidly earthed
- Ambient temperature : 50 degrees centigrade
- Temperature rise of oil over: 40 degrees centigrade ambient temperature.
- Temperature rises of winding: 50 degrees centigrade over ambient temperature.
- Impedance voltage : 4.5% to 6%
- Rated max. voltage HT/LT : 15 KV/0.6 KV
- Voltage regulation for rated: Not to exceed 2.5% of no-load operating condition at 0.85 P.F. secondary voltages.

**All values are subject to IEC tolerances**

**The transformers shall be provided with the following accessories.**

- Double float Bucholz relay for alarm and tripping with testing facility.
- Oil conservator.
- Silicagel breather, with oil bath
- Lifting Jugs
- Bi-directional rollers.
- Pressure release safety valve.
- Oil filling valve
- Oil drain valve
- Earth terminal
- Dial level gauge
- Dial type thermometer with maximum temperature indicator pointer and tripping facility.
- Diagram and name plate
- Pressure Release safety valve
- ON-load tap changer fitted with position indicator and pad-locking arrangement.
- HT porcelain bushings with protective spark gaps.
- LT and neutral porcelain bushings.
- Cable Termination Box on LT and HT side
- Marshalling box

The transformer tank shall be constructed of welded boiler plates and provided with external radiating tubes. The steel cover plate shall be bolted to the tank using gasket for perfect oil seal. The tank shall be anticorrosive painted and finished in grey colour.

The transformer core shall be built of non-aging, cold rolled, electrical silicon steel lamination and each lamination insulated to reduce eddy current losses. The core laminations shall be clamped and bolted effectively to reduce humming. The winding, coils shall be of high grade electrolytic copper conductor, flat or round, paper insulated thoroughly dried and impregnated as required.

The filling of oil shall be carried out at such a temperature that the pressure in the tank is at a minimum. The space above the oil shall be evacuated and filled with dry clean nitrogen. The pressure of nitrogen inside the top cover shall not exceed 0.35 kg/sq.cm.

Tank and terminal box joints shall be fitted with gaskets to prevent entry of water. Gaskets shall be of a suitable non-absorbent material. Joint faces shall fit properly and no additional thickness or jointing shall be used to make good irregularities.

The top cover shall have a substantial flange and adequate number of bolts fixing the cover to a similar substantial flange on the transformer tank. The gasket provided at this joint shall be of synthetic rubber bonded cork. Conservator tank shall be provided with Silica gel breather to allow for expansion of oil.

### **1.3 INSTALLATION**

Transformers shall be installed at location shown on the drawings. It is responsibility of the Contractor to check the provisions in civil works, related to transformer installation.

The installation of the transformer shall be carried out in accordance with specifications and the manufacturer's recommendations. The accessories shall be assembled, installed and connected in place so as to form a complete transformer assembly. The transformers roller wheels shall be locked after placing it in position so that the wheels do not move on the channel due to vibrations.

The MV cable connections shall be made on the HV terminal, provided on the transformer, by the Contractor as per manufacturer's recommendations. The cable compound and all other jointing / termination materials shall be provided by the Contractor without any additional cost. The neutral on the LV side shall be effectively connected to earth.

The control wires for Buchholz relay connections to alarm and trip contacts of the HT circuit breaker as distribution stations shall be installed in a heavy gauge steel conduit with transformer station and also it shall be run along the cable trench.

### **1.4 TESTING AND COMMISSIONING**

The contractor shall submit a detailed list of manufacturers recommended tests along with test procedures and intended results, for approval by the Consultant. Any additional test recommended by the Consultant shall be made part of the list of tests to be carried out on the transformers. The manufacturers recommend test list shall be submitted at least 2 weeks prior to the planned testing activities.

Testing of the transformer shall be carried out at the manufacturer's facility as well as at the installation location. All test procedures shall comply with the manufacturer's specified procedures and as per IEC standards. All testing procedures shall be carried out in the presence of the Consultant / Client. All expenses for witnessing the test procedures shall be deemed to have been included in the quoted prices. The quoted prices shall be inclusive of transportation of the transformer to and from the manufacturer's / approved testing agent's facility.

In case any test fails to comply with standards, manufacturers recommendations, the cause of failure shall be determined and removed. The equipment shall then be retested for compliance. Any material (transformer oil, silica gel etc.) found to be inadequate or failing the required test procedures shall be replaced within the cost quoted.

Upon complete installation of the transformer in its position, a thorough check shall be made for the proper fixing of accessories, protective relays, neutral connection, oil quality and level etc. The transformer shall be tested before energizing as per the Engineer's instruction. The transformer will be commissioned in the presence of the Engineer to satisfy its complete effectiveness and compliance with specifications. After installation, all tests as recommended by the manufacturer including connectivity of control equipment shall be carried out. In addition, the following shall be adjusted prior and subsequent to connection with the load.

## **1.5 TAPPINGS (ON LOAD)**

Transformer tapping shall be adjusted for no load and full load operation providing the desired output at any tapping. Adequate protection shall be ensured to prevent risk of damage from short circuits and having all contact surfaces of ample area for satisfactory operation during overloads.

The mechanism shall be motor operated and shall come to rest only when the switch is making full contact. At all times, clear indication shall be given of the ratio at which the transformer is operating. Means shall be provided for locking the tapping switch mechanism in the position corresponding to each voltage ratio.

All test values obtained during the test on the transformer shall be recorded. Triplicate copies of all such test datasheet (for both passed and failed tests) shall be submitted to the Engineer for necessary approval.

## SECTION – E – 4

### LOW VOLTAGE - LIGHTING CONTROL PANEL (LCP)

#### 1.0 GENERAL

The work under this section consists of design, manufacturing, fabricating, supplying, installing, connecting, testing and commissioning of all material and services of the complete weather protected outdoor type LV, Lighting Control Panel (LCP) as specified herein and shown on drawings and stated in Bill of Quantities.

#### 2.0 APPLICABLE STANDARDS / CODES

The latest editions of the following standards and codes shall be applicable for the materials specified within the scope of this Section:

BS 4752-1	-	Triple Pole Moulded Case Circuit Breaker
IEC 60947	-	Low Voltage Switchgear and Control Gear
IEC 60439	-	Factory Built Assemblies of LV Switchgear
IEC 60475-2	-	Switchgear & Control Gear for Voltages up to and including 1 kV
BS 88	-	HRC Fuses
IEC 60073	-	Colors for indicator lights and push buttons
IEC 60446	-	Identification of insulated / bare conductors

Any other standard referred to in above standards or these specifications.

#### 3.0 INSTALLATION AND SERVICE CONDITIONS

Distribution board shall be installed outdoor on concrete pad. The equipment shall be capable of operation under the prevailing ambient conditions without any deleterious effect of any kind. Distribution board shall be suitable for continuous operation at full load rating under combined variation of both voltage and frequency.

Transient voltage depression down to 80% of rated voltage shall not affect the performance of the equipment.

#### 4.0 ROAD LIGHTING CONTROL PANEL CONSTRUCTION

The outdoor Lighting Control Panel shall be sheet steel fabricated, suitable for floor mounting, totally enclosed, dead front, dust tight and vermin proof requiring front access only. It shall be complete in all respects with material and accessories, factory assembled, tested and finished all according to the specifications and to normal requirements. For outdoor installations, the international classification shall be IP-65.

The LCP with all components and accessories shall be suitable for front operation only and shall:

- Have a rated service short service-breaking capacity, as per BOQ, conforming to IEC 60157- 1, category P2 unless otherwise stated on the drawings.
- Be suitable for 400 / 230 Volts, 3 phase 4 wires, 50 Hz.
- Be designed for flush mounting of all instruments on the front side.
- Have incoming and outgoing cable termination arrangement, terminal block / line up terminals.
- Be provided with wiring diagram on inside of the door.
- Have all incoming and outgoing connections from top and / or bottom according to site requirements.

### **Construction Requirements**

The road lighting control panel shall be installed near transformer at location shown on the drawing. The contractor shall ensure coordination with the civil contractor to avoid damage to the completed works. The contractor shall provide foundation bolts and grout them in cement concrete with the approval of the Engineer. All installation material required for the satisfactory erection, such as bolts, nuts, washers and supporting steel etc. shall be provided and installed by the contractor for no additional cost. The panel shall be installed upright and in level and shall be firmly and rigidly fixed on the concrete supports. Panel shall be erected as per manufacturer's instructions and as approved by the Engineer.

Loose parts dispatched by the manufacturer shall be installed and connected as per assembly drawing. Any safety locking of meters relays etc. provided by the manufacturer for safe transport shall be released only after the panel is installed in position. The Lighting Control Panel shall be tested and commissioned in the presence of Engineer.

## **5.0 ACCESSIBILITY**

Distribution Board shall preferably be arranged for bottom cable entries. Adequate space must be provided for cable entries and termination.

Adequate space shall be provided for installation and clamping of cables inside the Distribution Board. Position of terminals and cables shall allow use of clamp ammeter.

Power and Control cable termination shall avoid obstruction to other cable termination and provide easy access for terminating cables. Cable supports shall be provided to avoid undue strain on cable termination. Easily accessible locations shall be reserved in the compartment for measuring transformers.

## **6.0 MECHANICAL DESIGN**

### **6.1 General Construction**

The enclosure of the LCP shall be fabricated from electro-galvanized / zinc coated sheet steel.

The LV outdoor LCP shall be fabricated with 15 SWG sheet steel concrete pad mounting. All components shall be installed on a common component mounting plate made of 14 SWG sheet steel inside the enclosure and protected from the front with screwed sheet steel front plate. The door and dead front covers shall be made of 14 SWG sheet steel. The door shall be fully gasketed with hinges on the left-hand side and locking handle on the right hand side for fastening the door. The locking handle should be detachable. The dead / front assembly shall be fastened to the enclosure by means of self - locating fasteners for quick and easy fixing.

The LCP shall be supplied complete with all installation materials as recommended by the manufacturer. The incoming and outgoing cable connections shall be according to the wiring requirements. If required, an adapter box for accommodating the cables and conduits may be provided. The box shall be of the same material and finish as the Distribution Boards.

An earth bar or terminal strips shall be provided for connection of incoming and outgoing earth conductors. The earth bar or terminals shall be permanently connected to the body of LCP at two points. Flexible copper strip shall be provided for earthing of the door of Distribution Board.

Neutral bus assembly shall consist of outgoing screw terminals with one terminal for each MCB. All holes, cut outs, etc., shall be tool or jib manufactured and free from burrs and rough edges. Removable gland plates shall be provided at both the top and / or bottom, as required.

The cabling inside the LCP shall be suitably numbered and harnessed by means of straps or cords. Wiring to door mounted components shall be in flexible PVC conduit. All indicating, control and selecting equipment shall be suitably arranged and clearly labeled with indelible labels indicating the rating of fuses, switches, etc.

All metal work of the distribution board shall be cleaned down to bare shining metal, phosphated and the surfaces chemically prepared for powder coating. Then these shall be coated with powder of color RAL 7032 and then baked in oven. The thickness of powder coating shall not be less than 120 microns.

All necessary interconnecting wiring within the control panel shall be carried out in the factory. Cable glands and lugs shall be provided as per requirement of incoming/outgoing cables. A suitable earthing terminal shall be provided inside the box. Crimping type lugs for incoming and outgoing copper cables shall be provided.

## **6.2 LABELING**

On the front side, a nameplate shall be provided at the top to indicate the name of manufacturer, system voltage and frequency and the current carrying capacity of switchboard.

Each breaker shall have a circuit identification label fitted below the breaker aperture or as suitable.

Drawing indicating the branch circuit names, breaker elements, cable sizes and connecting services shall be placed in a clear plastic pocket provided at the back of the front access.

Labels described shall have block letters 7 mm high on a white background, to be made from trifoliate and be fixed with screws.

Each incoming and outgoing circuit shall also be labeled with nameplate 75 mm x 15 mm, as described above on the front side of door.

The Distribution Board shall be supplied fitted with warning labels.

## **7.0 COMPONENT OF LV, LIGHTING CONTROL PANEL**

The LV, LCP shall be provided with all components as specified or shown on the Drawings and as necessary for the satisfactory operation of the LCP and of the electrical system. Typical specifications are given hereunder:

### **7.1 BUS BARS**

Bus bars shall be made of 99.9% high conductivity hard drawn electrolytic tinned copper, completely isolated and mechanically braced and rated to withstand the specified fault level.

Bus bars shall be clearly marked with their respective colors and these shall be red, yellow and blue for phases and white for neutral. The earth bus bar shall be green. Bus bars shall be provided for three phases, neutral and multi-terminal earth. The temperature rise shall not exceed 45 degree centigrade at rated current. Neutral bus assembly shall consist of outgoing screw terminals with one terminal for every MCCB / MCB.

Horizontal bus bars shall be of the same current rating throughout their length.

### **7.2 MOLDED CASE CIRCUIT BREAKER**

These shall be triple pole 400/500 volts or single phase 250 volts of current rating shown on the drawings. The breakers shall have both time delay over current and instantaneous short circuit protection.

The MCCBs shall be installed such that their switching levers are accessible through the dead front plate for operation. Circuit numbers / designation on all circuits shall be conspicuously marked to facilitate connection and maintenance.

The triple pole MCCBs shall have short circuit rupturing capacity suitable for distribution system as approved by the Engineer or as shown on the drawings. The MCCBs shall be suitable for lighting and power circuits.

The breaker shall have quick make - quick break toggle mechanism with positive 'ON', 'OFF' and intermediate 'Tripped' positions.

Trip mechanism shall be trip free on overload or short circuit ensuring that the breaker will not close / remain close even if the close command is given while the circuit breaker has tripped due to short circuit or continuing overload.

### **7.3 AIR BREAK CONTACTORS**

The contactors shall be air break, triple pole, 400 VAC and suitable for the type of duty to be performed. The main contacts shall be silver tipped, butt type with double break per pole. Each contactor shall be provided with single phase 230 VAC operating coil, one 5 watt 230 Volt red color signaling lamp, control fuse and two normally open and two normally closed auxiliary contacts wired up to terminals for electrical interlocking.

### **7.4 CURRENT TRANSFORMERS**

Current transformers shall comply with the requirements of IEC 60185 (or equivalent).

Current Transformers shall be polyester resin insulated, ring type, air-cooled having transformation ratio as indicated on the drawings. The Current Transformers shall be of suitable burden having accuracy class 1.0. The Current Transformers shall have rated secondary current 5A / 1A as required.

Current Transformers shall mechanically and thermally withstand the specified short circuit capacity.

### **7.5 PILOT LAMPS**

Distribution Board shall be provided with phase indicating pilot lamps. The lamps shall be rated for 230 volts supply and suitable for flush mounting. The front of the lamps shall have colored rosettes for identification of phases.

### **7.6 LINEUP TERMINALS**

Line up terminals wherever provided for Control or Power circuits shall be suitable for voltage and size of conductors as indicated on drawings. The Line up terminals for controls shall be suitable for channel mounting. All necessary accessories such as end plates, fixing clips, transparent label holder caps and label sheets with marking shall be provided.

### **7.7 AC VOLT METERS/AMPERE METERS**

Shall be Digital type and shall be suitable for flush mounting on front door of the LV Switchboards. The front dimensions shall be as per standard. The voltmeters shall have 3-1/2 digit, 0.55 inch display.

### **7.8 VOLTMETER SELECTOR SWITCH:**

The voltmeter reading shall be RY-YB-BR-OFF-RN-YN-BN positions.

### **7.9 SECONDARY WIRING**

All wiring shall be copper conductor, thermoplastic insulated, at least 1.5 sq. mm flexible, neatly arranged and clipped in-groups.

Each conductor and its termination are to be identified and marked with numbered ferrules. All live terminals are to be shrouded.

Secondary wiring for Current Transformers shall be carried out with not less than 2.5-sq. mm. Terminals shall be specially marked to avoid opening of the circuit by accident.

### **7.10 TIMER SWITCH FOR STREET LIGHTING CONTROL**

Timer Switch Operated shall be suitable for automatically switching street light ON & OFF. It should be possible to put it in service for any required time within 24 hours. The operating voltage shall be 220 volts between phase neutral, 50 cycle / Sec.

### **7.11 DAY LIGHT SWITCH FOR STREET LIGHTING CONTROL**

The street lighting circuits shall be controlled by photo-electric daylight sensitive switches. The Day light Switch shall be suitable for automatically switching street light ON & OFF.

One photo electric cell unit shall be provided to switch ON/OFF every contactor for control of lights. Photo-electric unit shall include a delay device to prevent the switching of lamps during transient changes in voltage. Each lighting circuit shall be equipped with Auto/Manual selector switch and ON/OFF push buttons for maintenance purpose without interference with the photo cell and whole to be enclosed in dust and vermin proof case. Since the light control panel is installed on road side, therefore its outer cover shall be plain, without electrical components. A brass batten holder with ON/OFF door switch and 30/60 watt CFL/incandescent lamp shall be provided at suitable location in the panel to facilitate maintenance during night time. Doors with hinges shall be provided so as to give maximum access for cabling and maintenance and shall be fitted with lock. Three sets of keys shall be supplied along with road lighting control box.

The operational level shall be factory preset for "ON" at a light level of approximately 54 lux and "OFF" at approximately 100 lux. Voltage variations shall not materially affect the operational levels.

A time delay of not less than 15 seconds shall be provided to prevent the unit from functioning due to short period changes in illumination.

The unit shall be effectively safeguarded against voltage surges by means of a suitable surge protector which shall preferably form an integral part of the unit.

## **8.0 INSTALLATION OF LCP**

All installation material for installation on concrete pad of LCP, junction box such as bolts, nuts; galvanized, washers, supporting steel, etc., shall be provided and installed by the Contractor. The LCP shall be installed upright and in level and shall be firmly and rigidly installed on concrete pad.

The Lighting control Panel shall be completely installed on concrete pad as per manufacturer's instructions and as approved by the Engineer. Loose parts dispatched by the manufacturer shall be installed and connected as per assembly drawing provided by the manufacturer. Any safety locking provided by the manufacturer for safe transportation shall be released only after the distribution board is erected in position.

The Lighting control Panel installation shall include all related civil works, termination of all incoming and outgoing cables. The cable armor shall be connected effectively to ground. All outgoing and incoming cable connections shall be made neatly and firmly to ensure good contact. Special care should be taken in fixing cable lugs and lead connections so as to have no danger of leakage during operation.

Appropriate entry holes for metal or PVC glands / bushes are provided in order to avoid danger to pulling cables.

The Lighting control Panel body shall be connected to earth as per instructions given in section "Earthing" of these specifications. The distribution board shall be tested and commissioned in the presence of the Engineer. The tests to be carried out shall be tested before energizing as per instructions contained in the article "Testing" of General Specifications of Electrical Works, section 1 of these specifications.

## **9.0 FOLLOWING PROTECTION SHALL BE PROVIDED**

- Triple pole series connected adjustable bimetallic over current release.
- Triple pole magnetic short circuit release.

Before procurement and installation the detailed shop drawings with make and type of the components shall be submitted to the Engineer for approval.

The manufacturer's recommendations shall be followed while installing the Lighting Control Panel. The LV Lighting Control Panel shall be tested and commissioned in the presence of the Engineer.

#### **10.0 TESTS AND INSPECTION**

The following tests and inspections shall be performed in accordance with relevant engineering standards:

- a) Visual inspection of appearance, construction, dimensions and workmanship, and
- b) Electrical and Mechanical operation tests.

#### **11.0 OPERATION AND MAINTENANCE MANUAL**

1. Prior to delivery of the equipment the Vendor shall submit three (3) sets of manuals for all equipment supplied under the contract. The manual shall be A4 size bound in a loose leaf binder or booklets suitably enclosed and shall include the following:
  - a) A complete set of all corrected drawings prepared by the supplier and approved, by the Engineer. All drawings included shall be folded to fit within the binders.
  - b) Setting up, commissioning and operation instructions.
  - c) Trouble shooting procedure.
  - d) Maintenance instructions including schedules for preventive maintenance.
  - e) Complete recommended spare parts list including manufacturer's name and catalogue number with all required ordering information.
2. Operation and maintenance manuals shall be prepared to allow the purchaser and operators to truly understand the product, its theory of operations, its application and performance.

## SECTION – E – 5

### LOW VOLTAGE CABLES AND WIRES

#### 0.0 GENERAL

This item shall consist of excavating trench, supplying, laying, testing, connecting and commissioning of all material and services of Low Voltage (LV) cables and wires and the accessories with or without conduits, backfilling and compaction according to the specifications, bill of quantities, drawings and/or as directed by the Engineer. The Cables shall be supplied from the approved supplier, as specified in approved manufacture list for the LV cables.

The Contractor shall discuss the electrical layout with client and coordinate at site with others for exact route, location and positions of LV cables.

The LV Works shall comply with requirements of relevant IEC and British Standards, the LV cables and wires with accessories shall also comply with the requirements of BOQ Item.

All cables shall be certified by the manufacturer as suitable for installation in Pakistan.

All materials shall be procured from approved Vendor. Only products with a proven record of performance, efficiency and long life will be considered for approval.

All works, equipment and materials shall comply with statutory and other regulations, Codes of Practice and Standards current at the date of Tender.

#### 1.0 MATERIAL REQUIREMENTS

All multicore and single core wires shall be as per Bill of Quantities. All single and three core sheathed cables shall be of 450 / 750 volt grade. Power cables for main feeders, main to sub main feeders, power equipment, etc., armored or unarmored shall be of 600 / 1000 volts grade. Armoring of cables shall be done with appropriate size galvanized steel wire as per codes.

The conductors shall be stranded, high conductivity, soft annealed copper. Conductor of single core cables shall be circular, whereas of multicore cables may be circular or shaped according to standard practices and codes. The PVC insulation shall be extruded with a PVC compound having good flexibility, resistance to aging and ability to withstand the ambient temperatures.

All the cables shall be suitable for operation in 400 / 220 Volts; 50 Hz three phase multiple neutral and Earthed Distribution System. The Electrical cable should be suitable for direct burial, for installation in air or running in the ducts/conduits. The maximum Ambient Temperature shall be 50<sup>0</sup> C.

## 2.0 Standards

Particular reference shall be made to:

- BS 6004 / 6346 PVC insulated cables for lighting and power.
- BS 6746 PVC insulation for electrical cables.
- BS 6360 Copper conductors
- BS 6500 Insulated flexible cords.

Any other standard referred to in above standards or these specifications

## 3.0 CONSTRUCTION REQUIREMENTS

The lighting and control cables shall be furnished and installed in accordance with the routes and requirements shown on the drawings.

The Voltage grade of the multi core LV Power cables shall be of 600/1000 volts.

All multi core cables shall be provided with identifications colour scheme, i.e. red, yellow, blue for phases and black for neutral. The insulated earth continuity conductors shall be having Green or green Yellow colour.

The ends of each length of multicore armored or un-armored cables shall be properly marked for clockwise and anti clock-wise sequence of core colors.

The armoured cables shall comprise of shaped stranded copper conductor, PVC insulated taped bedding, galvanized steel wire armour and PVC over sheath.

The insulation resistances of the cables shall conform to the relevant British Standard and these specifications.

All cable accessories shall be provided for the complete cabling and wiring system without any additional cost, unless specifically mentioned in BOQ. These shall include but not limited to the items such as saddles, clamps, fixing channels, connectors, cable joints (where necessary and approved by the Engineer), clips, lugs, tapes, solder, identification tags, bushes, Cable glands, etc.

Embossed marking on the over sheath at 3 meters intervals shall give the following information:

- Name of Manufacturer
- Year of Manufacture
- Size of cable in sq.mm.
- Voltage grade
- Type of cable i.e. Cu., PVC/SWA/PVC
- Project/ Client name (if required)

#### 4.0 INSTALLATION OF LV CABLES

Cable shall be laid as shown on the drawing, if the laying is effected by others utility services, the contractor shall test the cable characteristics insulation and continuity, of all phases and these shall communicate in a report to the Engineer/Client.

If cable is crossing the road extra protection of bricks, uPVC pipe class “D’ other than mentioned in underground cable laying detail shall be provided.

The cables shall be spaced by categories along their entire length as well as upon penetration into buildings and in their interiors, according to their following rated voltages:

- 30 cm at least between a cable carrying 1 kV – 30kV and other cables.
- 20 cm at least between a cable carrying voltages between 50V - 500V, and any power or control
- 10 cm at least between a cable carrying voltages lower than 50V and telephone or these possible being grouped.

All installation material, labor, tools and accessories for cable installation shall be furnished by the Contractor. The cable and accessories shall be installed as described in accordance with these specifications, drawings and manufacturer's instructions.

#### 5.0 INSTALLATION OF LV CABLES LAID DIRECT IN THE GROUND / PIPE

All the cables shall be laid in the trenches/duct according to the drawings or as directed by the Engineer. For burial of cables in ground, the following instruction shall be followed:

- a) The Contractor shall plan and take special care to prevent any damage to existing underground facilities such as underground piping, cables, foundations, etc. The Contractor shall notify the client of any obstruction encountered and shall provide protective support or removal of such obstructions as instructed by the client. Excavation adjacent to existing facilities, such as foundations manholes, ducts, underground pipelines and paving shall be braced and / or shored properly to protect those facilities during excavation and construction or elsewhere as designated, they shall be drawn into underground pipe ducts.

##### **Where cables**

- ❖ cross roads or other paved areas with vehicular access
- ❖ cross unpaved areas regularly used by vehicles
- ❖ Pass through corrosive soils.

A steel draw wire or nylon or polypropylene cord shall be inserted in each duct run immediately after its installation. A 2m surplus shall be left at each end of each run, neatly coiled and attached to a cross bar preventing the wire or cord from being drawn into the duct.

Underground pipe ducts shall be Heavy gauge un-plasticized PVC conduits with tapered sleeve or spigot and socket joints.

All ducts shall have a nominal internal diameter of 100 mm unless designated otherwise.

All dual systems shall be installed so that no undue strain is placed on cables when pulled in.

All underground cable ducts shall so far as possible, be run in straight lines.

Duct runs crossing roads shall be straight and, wherever possible, perpendicular to the axis of the road.

Except in the case of short isolated duct runs such as road crossings, underground cable duct runs shall terminate in draw pits.

Cable ducts passing under roads carrying heavy vehicles shall be completely surrounded with lean concrete to a minimum radial thickness of 150 mm.

Ducts shall be laid so as to drain naturally towards one or both ends, where adequate provision of drainage shall be made. Adequate precautions shall be taken to prevent the cable duct system acting as storm water or ground water drainage system. A minimum fall of 1 in 200 shall be provided for drainage purposes.

Any work carried out requiring the use of split ducts shall be carried out in such a manner as to preserve the withdraw ability of the cables concerned.

If two or more cables are to be installed in the same duct, the aggregate of their cross sectional areas shall not exceed 30% of the cross-sectional area of the duct.

All trenches excavated for the laying of cable ducts shall be completely backfilled and rammed before cable installation work begins.

Immediately following the installation of any duct run, the interior of the duct shall be thoroughly cleaned by twice drawing through the ducts a suitable brush once in each direction. Following this, the ends of each run shall be sealed with a suitable hardwood or plastic sealing plug which shall be left in position until cable laying is about to begin.

Before any cables are installed in the ducts, each duct shall be proved by drawing through it a polished hardwood mandrel 300 mm long having spherical ends and a diameter 6mm less than the nominal duct diameter.

Sufficient slack shall be left in cables for this purpose that cut lengths of cables shall allow about 3% more in the measured lengths between terminations.

Cables, whether installed underground or in concrete trenches, shall not be bent to a radius less than 12 times the diameter of the cable or as recommended by the cable manufacturer, whichever is higher.

All cables shall be marked at least at each end, switch gear and equipment termination, where cable enter or leave underground cable trenches or channels, where cable rises from one level to another, at 30M intervals with predetermined identification numbers, by means of proprietary non-deteriorating type, PVC, heat shrinkable, strap-on type or equivalent, for the identification of cable and circuit. These shall be indelibly marked with cable number and securely fixed to the cable. Where conductors are left to be terminated by another party or left to be connected later, they shall be identified. The earth continuity conductor shall be laid in the trench with the cables. When crossing road the cable must be drawn through pipes, which should extend upto the unpaved area.

- b) Low voltage cables shall be laid in PVC conduit at a depth of not less than 900 mm or as shown on the drawings. For external cabling, trenches shall be excavated as per the details shown on the drawings or as directed by the Engineer.
- c) The bottom of the trench shall be covered with clean sand or soft soil of minimum 100 mm thickness before laying the cables. After laying the cables they shall be covered with clean sand. The clean sand shall be placed well punned over and around the cables to a level of 100 mm above the uppermost cable. Mechanical punnets shall not be used. Protective cable tiles shall be carefully covered over each cable as per drawing. Polyethylene warning tapes with danger sign shall be laid below 300mm of finished ground level along the route of buried cables.
- d) It is the responsibility of the Contractor to take actual measurements of cable length, required between two termination points, as per drawings and site conditions and install single length of cables without joints of any nature.
- e) All cables shall be installed in continuous length; joints will only be permitted where manufacture of the cable in one length is not feasible. Marker slabs shall be provided above buried joints.
- f) Cable marker shall be placed on the finished ground level to identify the route of the cables on every 60m straight run, bends and joints.

## **6.0 CABLE TERMINATION AND JOINTS**

Cables shall be terminated in a safe, neat and approved manner at the associated equipment, included that erected by others.

Compression type connectors (lugs) shall be of the correct size and approved type for the conductors concerned. Compression tools shall be used for installation of Lugs. After compression, the conductor and terminal shall form a solid mass ensuring good conducting properties and mechanical strength. The Engineer or his representative before use must approve the compression jointing system used throughout the installation.

The Contractor shall be responsible for all drilling and if necessary, tapping entries where these have not been provided by others.

When preparing cables prior to fitting glands, the gland manufacturer's instructions for cable preparation shall be observed. In all cases where armored cables are used, care shall be taken to ensure that the lay of the armor is maintained after the gland is completely fitted.

Termination and joints shall be suitably insulated for the voltage of the circuits in which they are used.

Every compression joint shall be of a type, which has been the subject of a test certificate as described in BS 4579.

Cable ends, which are not terminated immediately after cutting, shall be sealed effectively to prevent ingress of moisture and shall be protected from damage until termination.

For all cables in section, if a substantial mechanical clamp is not provided a compression type lug or socket shall be provided. At all equipment, cable shall be installed and terminated so that no strain is imposed on the cable or gland and due allowance made to counter the effect of vibration. At all termination, an ample length of 'tail' shall be left.

Where joints in cable conductors and bare conductors are required, they shall be mechanically and electrically sound and they shall be accessible for inspection. Joints in non-flexible cables shall be made either by soldering or by means of mechanical clamps or compression type socket, which shall securely retain all the wires of the conductors.

Any joint in flexible cable shall be affected by means of cable coupler. Cable couplers and connectors shall be mechanically and electrically sound and shrouded in metal, which can be earthed. Where the apparatus to be connected require earthing every cable coupler shall have adequate provision for maintaining earth continuity.

**Data to Be Submitted**

The Contractor shall submit the following for approval of the Engineer before execution:

- Manufacturer
- Country of Origin
- Catalogue with indication of equipment proposed
- Detailed specification
- Construction drawings

## SECTION – E – 6

### ROAD LIGHTING

#### 1.0 GENERAL

The work under this section consists of supply, storage, installation, testing & commissioning of Road lighting system read together with drawings & bill of quantity. The Contractor shall furnish all labour, materials, services, and skilled supervision necessary for the construction, erection, installation and connection of all equipment. The extent of work specified herein and/or shown on the drawings represents the minimum requirements.

Electrical Work Generally is to be in accordance with the requirements of the Specification Road lighting including luminaries, columns, related power distribution and control, protective earthing and related works including column foundations and cables etc.

The design criteria for road lighting are based on the following parameters;

Luminance (L) cd/ m <sup>2</sup>	1.5 cd/m <sup>2</sup>
Overall Uniformity (U <sub>o</sub> ) = (U <sub>o</sub> + L min./L avg)	0.4
Uniformity of each lane (U <sub>l</sub> ) = (U <sub>l</sub> + L min./ Lmax.)	0.5-0.7
Threshold increment not exceeding	<10 %

The contractor shall be responsible and confirm in writing that his selection of equipment will ensure on the road surfaces luminance level and uniformities equal or better than those defined in the lighting design criteria as mentioned above.

The contractor shall submit the technical details of the luminaries and other equipment and having obtained conditional approval thereof; submit in duplicate, full detail of the calculated results for the level and uniformity of luminance and illumination on all road surface. These details should be submitted after initial approval by the Engineer.

#### 3.0 TECHNICAL REQUIREMENTS:

Minor deviations from the Drawings may be considered for improvement in construction details, but no changes are to be made without the written approval of the client/Engineer.

#### **4.0 AMBIENT CONDITIONS:**

Unless otherwise specified, equipment is to be designed and derated for continuous and trouble-free service at 50 °C ambient temperature and 100% relative humidity, with temperature reaching 70 °C in direct sunlight and with high content of ultra-violet rays. Equipment is to withstand full load operation whilst exposed to sun.

#### **5.0 SHOP AND CONSTRUCTION DRAWINGS:**

Contractor shall submit drawings for approval including, but not limited to, the following:

- a) Layout of equipment in exact positions with mounting and construction details, concrete foundation dimensions and reinforcement, routing and sections of duct- banks and trenches, backfill and packing material, earthing rods etc.
- b) Cabling and wiring diagrams, single line drawings, loads, phase distribution, protection and control, earthing.
- c) Calculations of illumination levels and glare, based on CIE methods.

#### **6.0 LED STREET LIGHTING SYSTEM**

The Road light operates from **Dusk to Dawn** i.e., the lamp automatically switches ON after the sunset and switches OFF after sunrise. The LED light should have programmable driver.

The light fixture shall be posted on single or double arm pole as shown in drawings. The luminaire shall be fixed on to the Pole and are interconnected through the cables. The street light operates in the stand alone mode.

The Street Lighting system components consist of:

- a) LED Luminaire
- b) Pole
- c) Interconnecting cables
- d) Terminal box & Circuit Breaker

#### **8.0 LUMINAIRES DESCRIPTION**

##### **Housing**

The fixture shall have a full die cast aluminum housing providing adequate rigidity, strength and heat dissipation.

The housing shall have intergrated driver and LED lamp compartments for better heat dissipaton and convenience in maintenance at the site, and shall feature highly reflective components and films to increase light output.

The optical LED compartment shall have thermally hardened glass cover and high quality silicon gaskets. The glasss shall be extra-white for maximum light transmission. The glass cover shall be tightly secured with housing.

**The complete fixture shall be rated for ingress protection class IP 66.**

### **Optics**

The fixtures shall have flexible optical systems for various wattage range.

The fixture shall use high efficiency LED and optics system.

The Light output Ratio (LOR) shall not be less than 85%.

The fixture shall offer a composite system efficiency of more than 120 lumen / watt.

The lens system design and high efficiency LED shall facilitate maximum spacing between the road lighting poles and coverage of wider roads.

The multilayer optics design shall ensure adquate luminance uniformity in the unlikely event of individual LED failure.

The fixture shall offer choice of narrow, medium and wide beam light distribution.

The optics lens system shall have choice of narrow, medium and wide beam light reflectivity for maximum light output.

### **Surge Protection**

The lighting fixture shall have surge protection to protect the eletronic driver and LED system. Minimum surge protection rating shall be 10 KV.

SPD should comply to IEC 61347-2-11 and should be listed in Luminaries IEC 60598-2-3

### **IP Protection / Impact Resistance**

The complete fixture including lamp and gear compartments shall have ingress protection class IP66 for Road Lights and IP65 for Flood Lights long reliable performance and minimal maintenance requirement and an impact Resistance of IK08 or above. No chemical glue shall be used as that may cause breakdown of water-proof and dust-proof seal.

## **Maintenance**

Both the driver and LED lamp compartments shall be designed to be easily accessible for maintenance.

## **Mounting**

The mounting of the fixture shall be in axial orientation through suitable sized sidearm. The means for attaching the luminaire or external part to its support shall be appropriate to the weight of luminaire or external part. The connection shall be designed to withstand wind speeds of 160 Km/hr on the project surface of the assembly without undue deflection.

## **Future Compatibility**

The fixture shall be fully compatible with future LED upgrades when they become available. It shall have a modular design to upgrade/replace with new LED modules or LED drivers at site conveniently with minimum effort. All electronic components/drivers shall be mounted on a separate tool-less gear-tray. Lamp compartment shall have easy access for opening the glass cover.

## **LED Driver/Electronic Control Gear for LED Modules**

The LED driver shall be designed to operate large array of high powered LEDs through current controlled output. The driver shall be suitable for 230V,+ 10%,- 15%, 50Hz, single phase mains AC supply.

The LED driver shall have an efficiency of at least 85%.

The LED driver shall be manufactured Harvard, TCL, Philips, Lumotech, BOSSLOH Schwabe, Lightech.

## **LED**

The LED chip shall be Philips, Lumild, Cree Nichla or Osram make.

The LEDs shall:

- Be designed for lumen maintenance of  $L_{70}$  or 70% at the end of useful life at ambient temperature of 35° C.
- Have a useful life of 50,000 burning hours.
- Have a minimum color rendering index (CRI) of  $70 \pm 10$  % and a color temperature above 5000K.

## **Thermal Management**

Managing thermal properties in LED fixtures is most critical to ensure optimum performance of LEDs and reliability of the system. The housing under the circuit board shall be specially designed to ensure perfect contact between the board and the fixture housing for efficient heat dissipation.

Only metal core PCBs shall be used to maximize heat transfer process and to offer reinforced electrical insulation via dielectric layer. The metal core PCB shall be mounted on the housing using a highly efficient thermal interface material. Use of silicon glue is not acceptable.

The housing over the driver chamber shall have additional ribs to ensure direct contact with the drivers. The housing shall have adequate surface area to ensure fast heat dissipation.

### **Photometrics**

Fixtures shall have Illumination Engineering society (IES) Type II or III distribution pattern, with short or medium longitudinal distribution. LM-80 LED and photometric test reports and IES files from a third party testing laboratory shall be available.

### **Warranties**

The complete fixture including all accessories shall have at least three (3) year warranty (after one year of defect liability period ) against defects and failures.

### **Applicable Standards and Codes**

The fixtures shall conform to the following latest standards and codes

- IEC 60598-1
- IEC60598-2-2
- IEC60598-2-3 ( Road & Tunnel Lights)
- IEC 60598-2-5 ( Flood Lights)
- IEC6247-1 ( For the complete fixtures being offered as well as for the LED Chips)
- LM-79 ( for the Luminaries being offered (Model/Wattage specific)
- LM-80 ( for LED chips being used)
- LM-82-12 ( Approved method of measuring LPW @ 50°C (Model/Wattage specific)
- UL-1598 ( For thermal management test, Model/ Wattage specific)
- EN 55015 : 2006 and 2007 – Limits and method of measuring radio disturbance characteristics of electrical lighting)
- EN 61547 : 1995 / +A1 : 2000 – Equipment for general lighting purpose EMC immunity requirements
- EN 61000-3-2 : 2006 – Limitation of harmonic current emission
- EN 61000-3-3 : 2006 – Limitation of voltage fluctuation and flicker
- EN 62493 Assessment of lighting equipment related to human exposure to electromagnetic field (Environmental friendly)

The LED driver shall conform to following latest standards and codes:

- EN61347-1: General and Safety requirements
- EN61347-2-13: particular requirements for DC or AC supplied electronic control gear for LED modules
- EN61384: DC or AC supplied electronic control gear for LED modules performance requirements
- EN 61548 : 1995 / +A1 : 2000 – Equipment for general lighting purpose EMC immunity requirements
- En 62384: AC or DC supplied electronic control gear for LED modules performance requirements
- Technical and descriptive data and drawings.

### **Technical and Descriptive Data and Drawings**

Technical and descriptive data and drawing to be submitted shall include but not limited to the following :

- i. Technical data of fixtures and driver
- ii. IES Photometric file ( absolute photometric data)
- iii. LM-79 test report for each of the fixture type/ wattage being offered.
- iv. LM-80 test report of LED used
- v. LM-82-12 approved method of measuring LPW @ 50°C (test report of the fixture type / wattage being offered.
- vi. Thermal management test report (UL 1598) of the fixture type/wattage being offered.
- vii. EN 62493 test report
- viii. IK rating test report
- ix. Lumen depreciation test report at 1000, 2000, 3000 and 6000 burning hrs.
- x. 3<sup>rd</sup> party IEC 60598 test reports
- xi. Vibration test reports
- xii. EMC test reports
- xiii. Salt spray test report
- xiv. Photo- biological safety test report
- xv. Customers testimonials
- xvi. Factory ISO certificate
- xvii. Report of other type tests stipulated in the respective standards/codes.
- xviii. Country of origin, Manufacturing works / factory details, premises & QA & QC procedure, in house testing procedure, routine testing procedures and test reports, testing equipment details are also being provided in order to ensure proper traceability and quality assurance on each piece of the product being delivered.

### **International Independent Laboratories**

For the specified requirements of type tests and type test reports by an independent authority/independent laboratory, the following laboratories shall be considered as independent laboratories:

- i) KEMA Labs, Holland.
- ii) CESI Labs Italy
- iii) CRIEPI Labs, Japan.
- iv) Any laboratory accredited by EA (European Co-Operation for Accreditation) or a member thereof.
- v) Any laboratory accredited by ILAC (International Laboratory Accreditation Cooperation) or member of thereof
- vi) Any laboratory accredited by IAF (International Accreditation Forum) or a member thereof.
- vii) Any laboratory accredited by STL (short-circuit Testing liaison) or a member thereof.

### **Installation Details**

When cables cross road, paved area or other services, they shall be laid in protective pipes of required size. The pipe end after installation of cable shall be plugged to make them water tight by means of bituminized hessian or equivalent material.

### **Standards For PVC Pipe/Accessories**

The pipe/accessories shall be manufacture according to the standards as below.

- |                 |   |
|-----------------|---|
| PS 4607 Part-1: | PVC CONDUITS AND ACCESSORIES (metric units) |
| BS3505:         | PVC pipes and accessories                   |
| BS6099:         | PVC conduits and accessories                |

**SCHEDULE OF TECHNICAL DATA TO BE FILLED IN FOR EVERY TYPE/MODEL  
& WATTAGE OF LED ROAD LIGHTING FIXTURE AND SEALED BY THE  
MANUFACTURER- (MANDATORY)**

DESCRIPTION	DATA/PARAMETERS/VALUES TO BE FILLED IN BY THE BIDDER/MANUFACTURER
Make	
Model	
Country of Origin	
Main applications	
Wattage	
Max. power consumption	
IES Photometric File (Yes/No)	
<b>Materials and finishing</b>	
-Housing	
-Gaskets type & characteristics	
-Optics	
-Glass Type	
Dimensions (LxBxH)	
Weight	
Windage area	
Classification code	
-IP Rating for fixture	
-IP Rating for Gear compartment	
-IK Classification	
-Class	
<b>Color &amp; material</b>	
- Frame	

-Hinge	
- Clip	
-Canopy	
Installation	
Maintenance	
<b>LED Chip Make, model &amp; country of origin</b>	
CREE (Yes/No)	
NICHIA (Yes/No)	
OSRAM (Yes/No)	
PHILIPS LUMILED (Yes/No)	
OR EQUIVALENT (duly type tested as specified and in full conformance to the technical requirements/specifications).	
LED Color consistency (SDCM ) Limits in %	
Optic	
Narrow Beam	
Medium Beam	
Wide Beam	
<b>LED Driver/Electronic Control Gear Make, model &amp; country of origin</b>	
Harvard (Yes/No)	
TCI (Yes/No)	
Philips(Yes/No)	
Lumotech (Yes/No)	
Vossloh schwabe (Yes/No)	

Ligtech (Yes/No)	
OR EQUIVALENT (duly type tested as specified and in full conformance to the technical requirements/specifications).	
Optical cover	
Line Voltage	
Mains voltage performance (AC)	
Min. Mains voltage operational	
Power Factor	
- At Normal Power	
- At Dim levels	
Surge protection	
- Differential Mode	
- Common Mode	
Earth leakage current [Max.]	
Light source	
LED driving currents	
System efficacy	
System lumen output	
Optics LOR (Light Output Ratio)	
CRI (Color Rendering Index)	
Color temperature as per ANSI C78.377A	
Ta	
Lifetime: Ta = 35°C @LM70	
Connector type & make	

Cable gland types & make	
Wire isolation (All wires are to be isolated singly)	
<b>Energy Saving Options</b>	
Dimming options	
-Programmable	
-No of Dimming levels	
-Wattage @ different Dimming Levels	
Warranty	
- Fixture	
-Driver	
- LED	
Future Upgrades and compatibility	
<b>Certifications and Type Test reports</b>	
<b>FACTORY ISO CERTIFICATIONS</b>	
<b>ISO 9000</b>	
Type Test Enclosed (Yes/No)	
<b>ISO 14000</b>	
Type Test Enclosed (Yes/No)	
<b>ISO 18000</b>	
Type Test Enclosed (Yes/No)	
<b>Fixture</b>	
<b>IEC 60588-1-2-3</b>	
Type Test Enclosed (Yes/No)	
Type Testing Agency	

<b>Photo biological Safety tests-IEC 62471</b>	
Type Testing Agency	
Type Test Enclosed (Yes/No)	
<b>General &amp; Safety Requirements - EN 61347-1</b>	
Type Test Enclosed (Yes/No)	
Type Testing Agency	
<b>LED Modules-Requirements of AC or DC supplied electronic control gear – EN 61347-2-13</b>	
Type Testing Agency	
Type Test Enclosed (Yes/No)	
<b>LED Modules performance requirements- AC or DC supplied electronic control gear - EN 62384</b>	
Type Testing Agency	
Type Test Enclosed (Yes/No)	
<b>Limits and methods of radio disturbance characteristics of electrical lighting EN 55015 : 2006 and 2007</b>	
Type Testing Agency	
<b>Equipment for general lighting purpose EMC immunity requirements EN 61547 : 1995 / +A1 : 2000</b>	
Type Testing Agency	
<b>Limitation of harmonic current emission EN 61000-3-2 : 2006 – Limitation of harmonic current emission</b>	
Type Testing Agency	

<b>Limitation of voltage fluctuation and flicker EN 61000-3-3 : 2008</b>	
Type Testing Agency	
<b>LM-79 test report for each of the fixture type/wattage being offered.</b>	
Type Testing Agency	
Type Test Enclosed (Yes/No)	
<b>LM-80 test report of LED used</b>	
Type Testing Agency	
Type Test Enclosed (Yes/No)	
<b>LM-82-12- Approved method of measuring LPW @ 50°C (test report) of the fixture type/wattage being offered</b>	
Type Testing Agency	
Type Test Enclosed (Yes/No)	
<b>Thermal management test report (UL 1598) of the fixture type/wattage being offered</b>	
Type Testing Agency	
Type Test Enclosed (Yes/No)	
<b>EN 62493- Test report</b>	
Type Testing Agency	
Type Test Enclosed (Yes/No)	
<b>IK rating test report</b>	
Type Testing Agency	
Type Test Enclosed (Yes/No)	

<b>Lumen depreciation test report at 1000, 2000, 3000, and 6000 burning hrs</b>	
Type Testing Agency	
Type Test Enclosed (Yes/No)	
<b>Vibration test report</b>	
Type Testing Agency	
Type Test Enclosed (Yes/No)	
<b>EMC test report</b>	
Type Testing Agency	
Type Test Enclosed (Yes/No)	
<b>Salt spray test report</b>	
Type Testing Agency	
Type Test Enclosed (Yes/No)	

## SECTION – E – 7

### POLES FOR ROAD LIGHTING

#### **Description**

These shall be manufactured generally in accordance with the latest edition of BS EN 40-2:2004 & BS EN 40-5:2002. The base plates and bracket arms (Single or Double) shall be manufactured as separate units and suitable for mounting or fixing on to the poles.

The galvanized Iron poles shall be of mild steel as shown on drawing from base plate to luminaire connection, well-proportioned and neatly finished. The height of the pole from the centre line of the spigot for luminaire connection to the ground line and out-reach of each arm from the vertical centre line of the pole to the tip of the spigot for luminaire attachment shall be as shown on drawing. Approval of the Consultant shall be obtained before ordering the poles for manufacturing.

#### **Applicable Standards/Codes**

The latest editions of the following standards/codes shall be applicable to the material specified within the scope of this Section:

BS 5649	-	Specifications for lighting columns
NV 65	-	Specifications for lighting columns
CM 66	-	Specifications for lighting columns
XP P 97 406-1	-	Specifications for lighting columns
ASTM A36	-	Steel for pole and Base plate
ASTM A307	-	Anchor Bolts
BS EN ISO 1461	-	Galvanization
ASTM A123 & A385	-	Galvanization

#### **Poles and Brackets**

Pole for road lights shall be both single and double bracket type and shall be fabricated from 4 to 6 mm thick MS sheet.

- (a) The poles shall be suitably designed for ground mounting. The J-bolt size shall be of 25mm diameter and of galvanized stainless steel grade SS 316. Each individual J-bolt shall be complete with washers and nuts (the quantity of J-bolt shall be recommended by the pole manufacturer/supplier).
- (b) Mounting details including all data, calculations, imposed loads and forces and dimensional drawings for the foundations required for the poles shall be endorsed by a registered Structural Professional Engineer.

- (c) The soil bearing capacity at the site shall be ascertained so that the foundations can be correctly designed.
- (d) Poles shall be made in such a way that only one (1) sheet of steel plate is used to form an octagonal/tubular pole. Welding shall be carried out along one edge of the poles only.
- (e) Poles seam welding shall comply with the latest edition of EN 1011-2 by automatic continuous welding process.
- (f) As bitumen coating shall be applied internally and externally to the base section of the poles, extra care shall be taken during the transportation and storage to prevent the poles from being dirtied by the bitumen coating. The poles shall be packed for transportation and storage in such a way that the clean galvanized surfaces are not side-by-side, below or above the bitumen coating. Wrapping of the bitumen portion with newspapers is not acceptable, as the removal of the latter will pose a problem. The protection of the bitumen from smearing the non-bitumen part of the poles shall be such that it could be easily removed during erection.
- (g) The material used for strapping the poles together during the delivery shall be of non-rust type. This is to prevent rust from appearing at the straps due to weather if stored for a long period.

### **Material Requirements**

The pole (vertical portion) along with base plate shall preferably be in one piece. But if manufacturing in one length is not possible, it can be in two or three pieces with force fit lap joint. The steel poles after fabrication shall be galvanized by hot dip process both in and outside as per BS-729. Hot Dip Galvanizing shall be carried out after removing grease, burs and slag etc. so that zinc coating is adherent, dense, smooth, continuous and uniform. The steel used in the manufacture of poles shall be made by open hearth or electric furnace process.

**The contractor shall ensure before placing of order that the firm has adequate facility for hot dip galvanizing process as per standard practice.**

The steel for poles shall have the following requirements:

Tensile Strength

- Minimum 39.9 kg/mm<sup>2</sup>
- Maximum 56.3 kg/mm<sup>2</sup>
- **Yield Point**
- Minimum 24.7 kg/mm<sup>2</sup>

### **Elongation**

for a 200 mm sample: = 20% min.

The straight portion of the pole shall be truly vertical and no deviation more than 100 mm in the entire length shall be accepted.

Other tolerances shall be as follows:

- |                          |   |              |
|--------------------------|---|--------------|
| - Outside diameter       | = | +1%          |
| - Wall thickness         | = | +10%         |
| - Overall Length of pole | = | +0.5%        |
| - Weight                 | = | -0.3%        |
|                          |   | +Not Limited |

The pole and the bracket shall be so designed that when subjected to wind at a velocity of 160 km/hour on the full projected area of pole, bracket and the luminaire; a factor of safety of 3 on minimum tensile strength of the material shall be obtained. In addition, the temporary horizontal deflections at the luminaire position shall not exceed 1/40 of the length of the pole above ground at aforementioned wind velocity.

**IMPORTANT: Adequate arrangements shall be made to restrict bracket to rotate around the axis of pole at aforementioned wind velocity.**

The poles shall have a base compartment, designed to accommodate a loop-in services cutout for 4 cores PVC/SWA/PVC cable of given sizes. An 8 mm stainless steel stud complete with nut and washers shall be provided in the base compartment of the pole for earthing purpose.

The edges of the door opening on the pole shall be reinforced with a 10 mm thick M.S square bar to reinstate the strength of this location. The opening cover shall consist of waterproof hinged door with rubber gasket. The door shall be provided with heavy duty non-rusting lock .

### **Construction Requirements**

Lighting poles shall be handled/transported and erected in such a way so as to avoid any damage. Any damage to pole or galvanizing shall be made good to the satisfaction of the Engineer. The lighting poles shall be stored clear of soil, ground water or other rust producing materials. The fixing of poles shall be carried out in accordance with manufacturer's instructions and good engineering practice.

The poles shall be erected in a true vertical position. The contractor shall be responsible until completion of the maintenance period for correcting the alignment of any pole/bracket from its original position except where it is due to vehicle impact.

Where lighting poles are to be installed in the vicinity of overhead power lines, the Contractor shall inform the Engineer and act as directed by him. Contractor shall number all the poles with high quality paint using stencil of 50 mm high lettering. The

numbering shall be at 1200 mm from the bottom of pole towards the road . The numbering shall be in a manner as directed by the Engineer.

Earth backfill around pole foundation, shall be done in 150 mm thick layers and shall be well rammed and compacted to provide full lateral support.

### **Pole internal wiring**

(a) An adequate length of PVC/PVC sheath cable, 3-core, 2.5 $mm^2$  rated at 450 / 750 Volts, shall be provided for the connection between the fuse cut-out unit and the Light Fixture. The cables shall be properly supported to prevent undue strain on the cable terminations. The cable color identification shall comply with the latest Standards

(b) The cables used shall be manufactured to the latest edition of IEC 60502-1.

### **Data To Be Submitted**

Before manufacturing, the contractor shall provide the following data.

#### High Mast/ Lighting Poles

- Manufactures
- Country of origin
- Type with manufacturer's catalogue and descriptive leaflet
- Details of construction with detailed specifications of material used for Column and holding down bolts
- Calculation showing details of stresses under maximum wind loading and gusting.
- Calculations and sizes for necessary concrete support bases
- Design calculation sheets for the poles from manufacture shall also be submitted by the Contractor to show that poles/foundations are safe for all specified stresses

### **TESTING OF ROAD LIGHT POLES**

#### **General**

The poles shall be tested and results recorded for each test by the manufacturer in the presence of an authorized representative of the owner or Engineer as stated below.

#### **Inspection**

The material, weight and dimensions of poles as specified shall be certified by the manufacturer. The Poles shall be inspected and in case being found below the limits of tolerance as aforementioned, shall be rejected.

## **Loading Test**

The poles shall be cantilivered horizontally and rigidly supported at base plate and loads applied at right angle to axis of the pole at some distance from top. The test items shall be as follows:

- Deflection test
- Permanent set test and Breaking Load Test

Sample comprising four poles shall be selected random out of each lot 50 and subjected to deflection test. One pole per 250 shall be tested for permanent set test and breaking load test. When the poles in Tender are limited in number, the manufacturer may avoid deflection, permanents set and breaking load test and supply results of tests already done for prototpye testing on such poles or supply calculation based results.

## **Galvanizing**

Weight, uniformity of coating and other requirments shall be strictly inspected in accordance with BS-729 or other relevant international standards.

## **Service Cutouts**

Each pole shall be provided with a waterproof and dust tight loop-in-service cutout accommodated in the base compartment of the pole.

The junction box shall comprise one (1) 6 A MCB single arm poles and two (2) 6 A MCBs for double arm poles ( all MCBs shall be capable of operating at 55° C ), a solid neutral link and earthing terminal. It shall incoporate arrangements for looping "IN" and "OUT" for 4 core upto 70 mm<sup>2</sup> PVC/SWA/PVC cable having copper conductor. The earth terminals, nuts and washers shall be adequately sized to take the earth continuity conductor with tight connections.

Dimensional drawing and details of the junction cutout box of pole shall be submitted for approval of the Engineer.

## SECTION – E - 08

### DIESEL DRIVEN ELECTRIC GENERATOR

#### 1. GENERAL

This specification covers the design, manufacture, supply, transportation to site, installation, testing & commissioning of Weather Protected, Sound Proof Canopy type floor mounted, diesel engine driven generating sets and all associated equipment with all labour and material required for commissioning.

The equipment shall comprise of completely self contained packaged, skid mounted units type for standby power supply including:-

Diesel driver  
generator and exciter  
automatic voltage regulator (AVR)  
control panel  
automatic control switchgear  
fuel day tank  
skid with trainable base-plate

#### 2. QUALITY ASSURANCE

##### ▪ APPLICABLE CODES AND STANDARDS

The Codes and Standards listed below, and any other publications referred to herein, shall be of the issue currently in force, shall form part of this specification and shall be applicable to the fullest practicable extent.

SO-9000 (BS 5750)	Quality Assessment Schedule
CP 321	Electrical Installations – General
CP 323	Private Electric Generating Plants
BS 649	Performance of Diesel Engine
BS 799	Fuel Storage Tank
BS 800	Radio & television Suppression
BS 5000 Part 3	General requirements for Rotating Electrical Machines Generators to be driven by reciprocating internal combustion engines.
BS 5514	Reciprocating Internal Combustion Engines.
IEC 6034 & ISO 8528	Diesel Generators

In the event of conflict between this specification and any specification or document referred to herein, the requirements of this section shall govern.

The Employer reserves the right to approve the manufacturer and origin of the equipment offered.

### **3. LOCATION AND CAPACITY OF GENERATOR SETS**

One No. Prime Set Generator shall be Installed for MCC Panel Pump Room , the rating shall be 60 kVA.

### **4. SITE CONDITION**

The units shall be designed for Prime power and shall be suitable for operating in the conditions of Karachi city as specified below :

- i. Altitude above sea level recommended by supplier
- ii. Ambient Temperature: 0 °C - 50°C
- iii. Relative Humidity 90%

### **5. ALTERNATORS**

The alternators shall comply with the relevant provisions of IEC-34-1 and also with new relevant provisions of the latest editions of BS 4999 and BS 5000 part 99 unless stated to the contrary in this specification.

Each alternator shall be designed for continuous running duty and shall be suitable for the following maximum current rating at the sea level, and maximum ambient temperature of 50°C and shall be capable of taking an overload of 10% 1 hour in any 12 hours operation.

The alternators shall be self-ventilating, open circuit, air cooled, salient pole, revolving field type with brushless excitation system. All the six stator winding terminal shall be brought out on the underside of the stator. Anti condensation heaters shall be fitted in the alternator stator and exciter and shall be arranged to automatically switch on when the machine is at rest.

The alternators shall run silently, smoothly and without vibration under all load conditions. The alternators shall be suitable for parallel operation. The cyclic irregularity and angular deviation of the Diesel engine alternator sets shall be within the limits specified in BS 649 on diesel engines.

The temperature rise of the stator windings above the ambient temperature of 50 °C as measured by embedded temperature detectors shall not be more than 70°C. The temperature rise shall be measured by at least six detectors suitably

distributed around the stator within the slots. All reasonable efforts shall be made to place the detectors at the various points at which the highest temperatures are likely to occur, in such a manner the they are effectively protected from contact with the coolant.

The temperature rise of the field windings shall be measured by resistance method and shall not be more than 80 °C above the ambient temperature of 50 °C.

The alternators shall be capable of continuously supplying their rated output at rated speed and rated power factor at a voltage that may vary between 95% to 105% of the rated voltage with a temperature rise limit not exceeding 5 °C. The alternators shall be designed to withstand 1.2 times the maximum rated speed.

## **6. EXCITER**

The Exciter shall be of the brushless type and mounted on the main shaft. The exciter shall consist of a three phase rotating armature with a shaft mounted, three phase, bridge rectifier and the generator shall be self excited. Surge suppresser shall be fitted across each diode bridge and an easily accessible fuse shall be connected in series with each diode.

## **7. AUTOMATIC VOLTAGE REGULATORS (AVR)**

The generator excitation system shall be provided with a fast response continuously acting automatic voltage regulator of the solid state type. The generator and AVR shall form a completely self-contained unit which requires no external supply for normal operation or for build-up purposes and the AVR shall be mounted in the alarm/control panel.

Failure of the AVR shall be detected by suitable excitation monitoring relay or relays which will switch the excitation control to manual control at a preset level.

Generator output voltage shall recover to at least 97% of rated voltage in less than:

- 1.2 Sec for 100% load
- Sec for 64% load
- 0.5 Sec for 30% load
- and will include low voltage detection relay if necessary

## **8. TERMINAL ARRANGEMENTS**

All six ends of the windings, properly marked, shall be brought out to terminals in terminal box located below the generator. The terminal box shall be suitable for the connection of 4 core, alternatively single-core, PVC/PVC cables, Protection shall be provided against excessive winding temperature.

Provision shall be made in the terminal box for solidly grounding the neutral point of the generator windings as per the recommendations of the manufacturer.

**9. GENERATOR WINDING TEMPERATURE DETECTORS (R.T.D'S)**

Six temperature detectors RTD's of approved design shall be embedded in generator stator winding, three being connected to a multipoint temperature indicator on the generator control panel, and three connected to an alarm relay. All terminations shall be made in a separate terminal box.

**10. DIESEL ENGINE**

Diesel engine shall be 12 cylinders, 4 stroke, direct injection, turbo charged, 1500 Rpm, complying with BSS 649 including the capacity to withstand 10% overload for one hour in any period of 12 hours. The engine shall be capable of running continuously to drive a directly coupled alternator to give continuous output at 0.8 power factor and at site conditions.

**11. ENGINE STARTING SYSTEM**

The main starting system shall be powered by nickel cadmium batteries. The batteries shall have a capacity to provide three cranking periods of 30 seconds followed by a 2 minutes rest period.

The arrangements for re-charging the batteries shall be by a constant voltage charger/rectifier unit with test facilities. The charger unit shall be capable of recharging the batteries is not more than 8 hours and shall automatically control the rate of charge.

The electric cranking motor shall be of the heavy-duty type with adequate capacity to crank the engine separately for six cranking periods without overheating.

**12. GOVERNING AND PARALLEL OPERATION**

The diesel engines governing shall be as specified in BS 649 Class A governing and shall be suitable for operation. The engine shall sustain the transient and permanent change resulting from change of motorized load, both off and on, by any step of 25% of the rated full load.

External governor droop adjustment shall be provided between 1 percent and 5 percent of rated speed. When running in parallel the set shall share load fluctuations equally.

An external means of adjusting engine speed between 5 percent at any load shall be provided at the governor.

The combined inertia of the diesel alternator set shall be such that the angular deviation in either direction from the position of uniform rotation shall not exceed 2.5 Electrical degrees. To avoid resonance, the natural frequency of oscillation of the rotating system, of diesel engine alternator sets when connected in parallel, must not approach the frequency of any engine impulses of significant magnitude.

The Contractor shall provide all other protection devices and accessories that may be necessary for the safe and efficient operation of the engines and the plant.

The engines shall be arranged for automatic emergency shut down upon the operation of the over speed, low lubricating oil pressure or high jacket water temperature. Arrangements shall be made to ensure simultaneous opening of the circuit breaker and operation of the field suppression gear in the event of an emergency shutdown due to over speed.

### **13. COOLING SYSTEM**

The diesel engine shall be water cooled by means of a closed circuit cooling system. Suitable inhibitors shall be added to the cooling water to protect the cooling system against corrosion and sludge. The cooling water shall be circulated by a centrifugal pump fitted on the engine. The heated up cooling water shall be cooled by a fan driven from the engine. The radiator shall be fully tropicalised and suitable for site weather condition. The radiator shall be of the free standing type which can be remotely mounted from the engine. It shall be complete with its own electrically driven fan which shall be arranged to start automatically when the engine starts and runs up to speed. The fan motor shall be provided with a star-delta starter. The cooling system shall be suitable for jacket cooling, oil cooling and charge air cooling.

### **14. FUEL OIL SYSTEM**

The fuel oil system shall consist of a service tank (24 hr/7day tank) for the engine, and shall have a capacity for at least 01 week operation at full load for each engine. It shall be fitted with an electrically operated pump, with a provision for manual operation for refuelling from reservoir tank. A hand pump shall be provided as a back-up facility in the event of the electric pump failure. Oil/Water separator shall be provided with engine fuel system.

The fuel system shall be installed with a necessary interconnection piping and accessories and each tank shall be provided with the following equipment.

- Electric pump for filling the services tank from the bulk storage tanks.
- Level gauge or level indicator complete with scale indication to measure the daily fuel consumption.
- Low level float switch for signalling and alarming a low fuel level.
- overflow pipe complete with bell mouth and connection pipe to oil sump,
- inlet/outlet connection with isolating valves and fire valve,
- vent and drain with connection to the oil sump;
- inspection hole;

#### **15. LUBRICATING OIL SYSTEM**

The lubricating oil system shall be closed-circuit forced feed type with double filter and with an automatic by-pass to avoid stoppage of oil circulation. Provision shall also be made for draining the entire system for cleansing when necessary and for re-filling the system. The system shall be complete with simplex pattern oil filters of replaceable element type having service indicator, oil cooler, oil pressure indicator and low oil pressure alarm. The whole system shall be such that it is suitably protected from ingress of dust and moisture. The oil cooling shall be directly via a section of the main radiator through an independent circuit.

#### **16. AIR INDUCTION AND EXHAUST SYSTEM**

The combustion air intake system shall be complete with extra heavy-duty air-filters, necessary piping, fixture, etc. to supply clean air to the inlet manifold even under conditions of storms heavily charged with fine dust. The air-filters should be such that they can be reused after cleaning. The charge intake shall be exhaust gas turbocharged and inter cooled. The turbo-charger shall preferably be located at the free end of the engine.

The exhaust system shall include exhaust, muffler, silencer, exhaust manifold, expansion joints, bellows, flexible coupling, insulation etc. The bellows shall be of stainless steel and shall be flexible as that they can be able to bear thermal expansion and vibrations. These shall be fitted to the outlet of the turbo-chargers. They shall be provided as loose items for installation in the exhaust system pipe work as suitably required.

## 17. ALARM AND CONTROL PANEL

Provisions shall be made at the engines for manual starting, stopping and speed variation. In addition to manual control of engine speed at the engines, speed adjustment shall also be provided by remote electrical operation from the control room. Each engine shall have its own control panel of floor standing type, sheet steel construction. Access to the panel shall be by lockable doors which shall be properly braced. Neoprene gasket shall be fitted on all doors and gland plate. The gland plate shall be fitted at the bottom of the panel.

Nameplate shall be fitted to the outside of the door. Nameplate shall be of the black phenolic lamination etched to show designation in 12mm white letters in English and Arabic.

The panel shall contain the following instruments and all relays necessary for starting & shut-down the engine with visual indication, when the performance level exceeds the recommended level. In addition it shall be equipped with the following as minimum requirements:-

- Tachometer
- Jack water temperature gauge
- Lube oil temperature gauge
- Lube oil pressure gauge
- Winding temperature gauge
- Cylinder exhaust temperature gauge
- Turbo charger inlet & outlet temperature gauge
- Turbo charger delivery pressure gauge

In addition the panel shall be equipped with the following as a minimum requirement.

- Voltmeters and voltmeter selector switch
- Ammeter and ammeter selector switch
- Frequency meter
- Hoarse run meter
- kWh – meter
- Manual start/stop push buttons
- Selector switch for auto/manual/test start
- Engine speed adjustment controller
- Alarm and fault indicating lamps
- Lamp test button
- Reset button

- Automatic Voltage Regulator
- Synchronizing Equipment
- Provision shall be made for audible alarm along with visual indication, when shut-down of the engine occurs for the following faults.
- Low Lube Oil Pressure
- High Jacket Water Temperature
- Over speed

The shut-down relay shall be provided with at least two normally loosed spare contacts for remote connection.

Each control and indication system shall be on separate circuit each of which shall be fused.

All wiring inside the panel shall be of single core 2.5 mm<sup>2</sup> copper conductor PVC insulated. All wiring shall be neatly formed and supported; wherever possible this shall be accomplished by enclosing wiring in rugged, non wrapping panel wire channels of insulating and flame-retardant material with removable top covers.

All panel devices shall be wired to 600V rated terminal block. All wiring terminating on terminal block shall be identified on the marking strips and all other wiring termination shall be identified by numbered ferrules.

All relays, indicating lamps and controls installed in the panel shall be suitable for operation on 230V single phase 50 Hz system. If the supplier wishes to offer some other A.C. single phase voltage then a suitably sized transformer shall be installed inside the panel.

## **18. FULLY AUTOMATIC PANEL**

The control system switchgear shall be designed to automatically program the operation of the station engine generator based on load demand. It shall be sensing the load automatic by units. As the existing load shut downs the standby units shall be automatically programmed into operation. As existing power supply appears, the standby units shall be automatically removed from service. Automatic load sharing shall occur after closure of the generator circuit breakers and shall be a function of the engine governor system. Voltage regulation shall be a function of the generator automatic voltage regulator systems.

An engine generator set fail to automatically parallel or develop a circuit running monitored fault, the control system shall cause the engine to automatically shutdown with its circuit breaker automatically tripped open.

The design of the control system shall also permit manual starting, stopping and paralleling of the station engine generator sets at rated speed and voltage.

The Minimum instrumentation, controls and protective devices for each generator set shall be as follow;

- AC ammeter
- AC voltmeter
- Selector switch circuit
- Frequency meter
- Transducer Indicator, scaled in watts
- Elapsed (running) time meter
- Ammeter Phase selector switch
- Voltmeter Phase selector switch
- Reverse power relay
- Stator temperature Relay, solid state type, field adjustable trip points for alarm and shutdown
- Mounting and wiring of pre-programmed module and automatic load share among generator sets.
- Manual speed adjusts potentiometer to use with load share governor module.
- Voltage adjust rheostat for use with automatic voltage regulator devices.

Automatic Module to sense and compare the incoming generator set voltage, frequency and phase angle with the live bus and to provide automatic close signal to the incoming generator breakers when these are within Synchronizing tolerances. The automatic monitor shall be capable of providing automatic correction signals to automatic load share governors.

- Lamp test monitoring push-button.
- Indicating LED's for the following.
- Engine in No-load cool-down mode.
- Generator running in auto mode.
- Fail to automatically parallel.
- Generator in standby mode.

The Common/Master Control Panel shall include the following:

- Station alarm horn with silence pushbutton.
- Integral swing panel section for use in manual parallel and to include:
- Bus frequency, incoming genset Voltmeter, Incoming genset frequency meter.
- Kilowatt hour meter
- Power factor meter
- Mounting of voltage regulator devices, voltage adjust rheostat
- Control switch with positions Reset/Auto/Manual/Stop Cool-down
- Low battery voltage fault alarm.
- Pre lube oil pump running indicating LED.
- Emergency stop push button turns to reset type.
- Alarm and LED indications for the following:
- High Jacket water temperature fault shutdown.
- Low engine lube oil pressure shutdown.
- Engine over speed.
- Engine over cranked/failed to start shutdown.
- Engine control module diagnostic fault.
- Engine mode selector switch not in position.
- Warning high jacket water temperature.
- Warning low engine lube oil pressure.
- Warning engine over speed.

#### **19. FOUNDATION**

Provide a suitable reinforced cement concrete Pedestal for both the D-G set and fuel tank with concrete proportion of 1:2:4. RCC bed should rise at least 0.3m above the ground level.

#### **20. EARTHING**

The Generator Neutral should be earthed with 2Nos. of Copper rod earthing as per BS 6043.

#### **21. ACOUSTIC AND WEATHER PROOF ENCLOSURE**

Design, fabricate, supply and install outdoor type acoustic and weather proof enclosure for the healthy operation of D-G set at site. The enclosure should be well fabricated structure using 14 SWG sheet steel on all sides.

Provide sufficient working clearance around the D-G set inside the enclosure.

- a. Special acoustic panels of optimum sound attenuation using special aluminium sheets (perforated) and acoustic grade high density wool sandwiched with gypsum.

- b. Self insulated ventilation louvers for proper air aspiration and temperature control with suitable incorporation of special blower / axial fans of heavy duty depending on the on-site fresh air needs.
- c. Corrugated steel frames and sturdy supporting material for housing the panels, effective sealing with the right gasket/ neoprene materials.
- d. Well fabricated / nylon wheeled smooth sliding doors to be provided for easy access to the set. Suitable locking arrangement has to be provided on the doors.
- e. Aesthetic finish ( with intensive painting care ) for perfect integration with the surroundings.
- f. Noise level should be less than  $65 \pm 3\text{dB}$  at 3 meter distance from the enclosure.
- g. Acoustic and weather proof enclosure system should be complete in all respect as per prevailing standards.
- h. Adequate and suitable lighting arrangement inside the acoustic enclosure shall be made.

Note ; Separate DP MCB with control box to be provided for Lighting and blower fans

## **22. EXECUTION**

### **Installation**

The generating set shall be installed in strict accordance with manufacturer's instructions, recommendations and drawings. All mechanical and electrical erection and interconnections shall be made with due care of safety for personnel and equipment.

### **Work Testing**

Tests shall be conducted at the manufacturer's works.

Engine mechanical tests shall be in accordance with British Standards.

Electrical tests shall be in accordance with BS Standards and include but not limited to:

- Open circuit characteristics
- Short circuit characteristics
- Winding resistances
- Insulation resistances
- High voltage withstand test
- Over speed test
- Phase sequence test
- Vibration test
- Momentary overload test

The unit shall be subjected to a temperature rise test and sudden short circuit test and the test certificate shall be provided.

Full functional tests shall be carried out on the automatic voltage regulators with simulated inputs, where necessary. Response to sudden shedding and application of 25%, 50%, 75% and 100% of rated load.

The Contractor shall test the alarm control panel as a complete unit with all equipment in position and connected to a temporary supply. Similarly, functional test shall be performed on the automatic transfer switch. The complete panel with all equipment installed and connections made shall be tested electrically for continuity and insulation.

The complete unit shall be run at full rated load for 24 hours continuously. Continuity and insulation tests shall be repeated immediately on completion of the 24 hours soak. The operation of all electric and electronic instruments shall be tested and recorded.

### **23. PERFORMANCE DATA**

The Contractor shall also provide the performance data of the generator carried out at manufacturer's yard before shipment.

Particulars of Performance Data Corresponding to various load tests

- Ambient air temperature
- Ambient relative humidity
- Cooling water temperature
- Starting and stopping function
- Control and alarm functions
- Engine speed RPM.
- Fuel consumption rate
- Oil consumption rate
- Power to engine auxiliaries
- Electrical load applied
- Voltage per phase
- Current per phase
- Frequency
- Functional test of synchronizing switchgear

## 24. START-UP AND COMMISSIONING

On completion of the site installation conforming to CP 321, (general), CP 323 (EGP), the initial startup shall be performed by a manufacturer's representative in the presence of the Client's representative. The Contractor shall carry out full site load and no load tests in accordance with I.E.C. ISO or BS specifications for site commissioning. The inspection and tests shall include but not be limited to:

<b>Basic Tests</b>	Insulation Resistance Earth Continuity Earth Loop Impedance Polarity Phase Rotation Voltage and Frequency Starting System Protection Equipment Starting System Protection Equipment
<b>Battery:</b>	Standing Voltage Discharge Voltage Specific Gravity of Electrolyte Level of Electrolyte Charging System
<b>Lubrication:</b>	Check as required by manufacturer
<b>Operational Check at Start-up</b>	Oil Pressure Fuel Oil Leaks Operation of Safety Devices Operational Speed Automatic Control Instrument Check Exhaust Check Undue Vibration
<b>Operational check after one hour's run</b>	Oil Pressure Oil Leaks Cooling System Oil Temperature
<b>Commissioning Test</b>	25% of full load 1 hr 50% of full load 4 hrs 75% of full load 4 hrs 100% of full load 4 hrs 110% of full load 1 hr

All commissioning and test results shall be recorded and compared with design data. A retest/commissioning shall take place if results are not satisfactory. All the tools, labour, POL, required for the testing and commissioning shall be provided by the Contractor at no extra cost. If required load is not available at site for testing the generators, the Contractors shall provide dummy load at site at no extra cost to the Client/Employer.

**25. WARRANTY**

The Contractor shall provide warranty for the generator sets for one year or 8000 hours from the date of commissioning, whichever occurs earlier.

**26. PAINTING**

Painting shall be in accordance with manufacturer's standards for all equipment located within the power house. Externally mounted equipment such as the silencers and the main fuel storage tank shall be painted in accordance with the overall painting specification and be suitable for operation in a marine coastal environment.

**27. TECHNICAL DATA**

The Vendor shall provide, along with the bid documents, complete technical data for alternator AVR, space heater, engine, engine auxiliaries, engine control and alarms, fuel & oil consumption rate, efficiency of Engine & Alternator, switchgear, and derating factor for site ambient.

**28. TOOLS & SPARE PARTS**

Tools necessary for the top overhauling, maintenance etc. shall be supplied with each generating set as recommended by manufacturer.

2500 Hours maintenance spares for each generating set, alternator and panel, shall be supplied by the Contractor as recommended by the manufacturers but the following spares must be included for each Diesel generator set.

Sr.	Description	QUANTITY
1.	Oil Seal Rear	1 No.
2.	Oil Seal Front	1 No.
3.	Cylinder Head Gasket Set	1 No.
4.	Fuel Pump Gasket Set	1 No.
5.	Filter Lubricating Oil	6 Nos.
6.	Fuel Filter Element	6 Nos.
7.	Water filter Element	4 Nos.
8.	Air Filter	2 Nos.
9.	Start Push Button	1 No.
10.	Piston Rings Set	1 Set.
11.	Fan Bells	1Set.
12.	Indicator Bulbs	10 Nos.
13.	Relays with indicator one each (as fitted in panel)	1 Set.
14.	Fuses 2 Amps and 5 Amps each	5 Nos.
15.	Fuses 10 Amps and 15 Amps each	5 Nos.
16.	Selector Switch	1 No.
17.	Voltage build up resistor if installed	1 No.
18.	Variable Resistor if installed 1 No.	1 No.
19.	Radiator Cap.	1 No.
20.	Sp: Gravity meter for battery	1 No.
21.	Bearings (for alternator)	1 No.
22.	Sump Heater	1 No.
23.	Khr. Meter	1 No.
24.	AVR Unit	1 No.

## SECTION – E – 9

### EARTHING SYSTEM

#### 1. GENERAL

The work covered under this section of the specifications consist of furnishing all labour, equipment, appliances and materials and in performing of all operations in connection with providing, installing, connecting, testing the earthing system complete in accordance with this section of specifications and drawings. The earth pits on the drawings are only indicative and these will be located as directed by the Engineer.

#### 2. APPLICABLE STANDARDS AND CODES

- BS 951 - EARTHING CLAMPS
- BS 7430 - EARTHING
- BS 2874 - NUTS,BOLT,WASHER,SCREW & RIVETS FOR USE ON COPPER
- BS 1433 - HARD DRAWN BARE COPPER CONDUCTOR FOR EATHING.
- BS 6346 - PVC INSULATED CABLES.

The maximum values of resistance of equipment earthing systems to the body of earth shall be as follow:

- General Electrical Earthing 1 $\Omega$
- Earthing For Static Discharge 1000 $\Omega$
- Earthing For Lightning Protection 10 $\Omega$
- Instrument Clean Earth 1 $\Omega$

#### 3. EARTHING ACCESSORIES

The Earthing system shall be consist of Earth electrodes, Earthing leads, Earth connecting point, Earth continuity conductor and all accessories necessary for the satisfactory operation of the associated electrical system.

##### a. Earthing by Earth Copper Plate

The earth electrode Copper plate shall consist of 600mm x 600mm x 3mm thick 99.9% high conductivity electrolytic tinned copper plate. The plate shall have four terminals for connecting the earthing leads as shown on the drawings.

**b. Earthing by Earth Copper Rods**

The earth copper rod shall be installed for Lighting poles, LCP, transformer and others as indicated in drawings. The copper rods shall be of 3m length and 20mm dia with high conductivity electrolytic copper. This shall be driven into the ground to the full length as shown in drawing.

**c. Earthing Lead**

The earthing lead shall connect the earth electrode to earth connecting point or equipment. It shall be round hard drawn bare electrolytic copper of size shown on the drawings. The cost of earthing leads deemed to have been included in the price of earth electrode & no separate pavement shall be made for it.

**d. Earth Continuity Conductor**

Earth continuity conductor (E.C.C) shall be hard drawn bare copper wire or single core PVC insulated copper conductor cable of sizes indicated on the drawings or BOQ. All thimbles, lugs, sockets, nuts, washers and other accessories necessary for the complete installation of ECC shall be provided by the Contractor without any extra cost. PVC insulated cables when used as E.C.C. shall be green or green yellow.

**e. Earth Connecting Points**

When copper plates or copper rods are used as earth electrodes, the earthing leads from the plate or rod shall terminate at the earth connecting points which shall be of tinned copper bar, rectangular in shape, having dimensional 500mm x 50mm x 10mm, installed in the wall of the inspection chamber at the ground level. Further connections to respective locations shall be made from this bar by earth conductors of various sizes as shown on the drawings.

**f. Inspection Chamber**

At the ground level an inspection chamber shall be provided size shown on the drawing. The inspection chamber shall have 50mm x 50mm angle iron frame at the top to accommodate an approved quality heavy duty cast iron or concrete cover with handle. The cover shall have "EARTH BELOW" inscribed on its top. The Contractor shall provide and install the cover flush with the ground level.

**4. EARTH INSTALLATION**

Complete earthing systems as shown on the drawing shall be installed by the Contractor. The earthing system shall give earth resistance, including resistance of soil, earth leads and E.C.C. equal to less than one ohm, this without ground pits water spraying.

The earthing system shall be loop connected with earthing cables at least 300 mm away from telephone cables. The concept of the main loops and the way they are connected shall be such that equipment / apparatus can be easily removed without requiring a complex disconnection operation nor risking interruption of / or damage to the loop itself. The fastening of the earthing conductors shall be made on a sufficient length so as to prevent crushing or cross section weakening. The parts on which they are connected shall be conveniently cleansed and surface.

Lead sheaths or steel tape armours are not permitted as grounding conductors. The earthing system shall be installed to ensure that when any part of the earthing system is disconnected for the purpose of carrying out periodic testing an alternative path to earth is available.

At all connections of earth continuity conductor to MV/LV Switchboard, LV Distribution Board or any other metallic body, proper size or brass sockets, thimbles or lugs shall be used to which the copper wire shall be connected by copper brazing. The soldering of copper wire at joints or termination shall not be allowed. All tee-off connections shall be by copper brazing using suitable socket and clamps. After brazing, the jointed surface shall be protected by oxide inhibiting compound of low electrical resistance. For connections to metallic body, the surface shall be thoroughly cleaned before bolting the lug or socket.

The earth continuity conductor shall be in general run in cable trench or in conduits / pipes as shown on the drawings. Where laid along underground cables these shall be laid directly under ground in unpaved areas and in pipes under paved areas.

The earth connecting point shall be installed at locations shown on the drawings. It shall be fixed on wall surface by means of brass screws with nuts, washers and other insulating material as instructed by the Engineer.

The earth continuity conductor of sizes shown on the drawing shall be installed all along the cable runs and connected to the earthing bar / terminals provided in the equipment. The body of all Switchboards shall be connected to earth by specified size of E.C.C. All metal work shall also be connected to earth by specified size of E.C.C.

At any joint or termination, the E.C.C. shall be connected using proper accessories. No connection shall be made by twisting of earth conductors.

▪ **Installation of Earth Electrode (Copper Plate)**

The installation of earth electrode (copper plate), a pit of appropriate diameter and up to the depth of 4 m or (as directed at site) shall be first excavated in the bare ground. The earth electrode shall be installed upright in the pit and shall be surrounded by **mixture of lime and charcoal** around the electrode as shown on the drawings and packed hard. From the plate earthing leads of 2x70mm<sup>2</sup> bare Cu. Conductor shall be taken to the bus bar in the inspection chamber through 50mm G.I pipe for watering purpose.

▪ **Installation of Earth Electrode (Copper Rod)**

The earthing system by copper rod shall consist of 20mm dia and 3 meter long copper rods. These shall be of 99.9% purity copper. These shall have screw able head to accommodate other rods in series with the help of dowel as is shown in the drawings. The driven head shall consist of a hardened tip. These rods shall be connected to the earthing lead whose other end shall be connected to the earth connecting points to be provided in the inspection chamber. From the earth connecting points earth connection shall be made to individual point as marked in drawing.

▪ **Installation of Earth Electrode where the condition not suitable for Earthing**

Where the rock lie just below the surface or water table are very deep then earth electrode shall be installed through drilling or digging method. Due to certain ground conditions make it difficult to obtain a reliable earth resistance, whilst particular installations may require a very low resistance. In such cases, **Marconite concrete** shall be used as backfill for a conventional earth rod achieve a lower earth electrode resistance.

**5. Equipment Grounding**

a. **Non-current carrying metal parts:**

Bond and ground non-current carrying metal parts of electrical apparatus and equipment provided under work of any section of specifications.

b. **Grounding of Fence:**

All metallic fences shall be grounded by driving earth rods at a distance of 50 meter.

**6. Inspection and Test**

Earth resistance test shall be made by the Contractor on the complete earthing system in the presence of the Engineer. The test result shall conform to BS 7430 (formerly CP 1013) and BS 6651 (Formerly CP 326). To obtain the desired result more earth rods shall be provided.

## **SECTION – E – 10**

### **TESTING OF ELECTRICAL EQUIPMENT**

#### **GENERAL**

Upon completion of the installation the Contractor shall perform field tests on all equipment, material and systems all tests shall be conducted in the presence of the Consultant/client's Engineer for the purpose of demonstrating equipment or system compliance with specifications. The contractor shall submit test protocol for approval atleast two weeks before conducting the test.

The Contractor shall furnish, install and maintain all tools, instruments, test equipment, material, connections, etc and furnish all personnel including supervision and "Standby" labour required for the testing, setting and adjustment of all electrical facilities and their component parts, including putting the same into operation.

All tests shall be made with the proper regard for the protection of the equipment and the Contractor shall be responsible for adequate protection to all personnel during such tests.

The Contractor shall record all test values of the tests made by him on all equipment, giving both "as found" and "as left" conditions. Three (3) copies of all test result shall be given to the Engineer Incharge for record purposes.

The witnessing of any test by the Engineer In charge does not relieve the Contractor of his guarantees for materials, equipment and workmanship as specified in the Conditions of Contract.

#### **INSULATION RESISTANCE TEST**

Insulation resistance tests shall be made on all electrical equipment, using a self-contained instrument such as the direct indicating ohm-meter of the generator type Direct current potentials shall be used in these tests and shall be as follows:

Circuit under 230 volts – 500 volts test

Circuit 230 volts to 400 volts – 1000 volts test

The minimum acceptable insulation resistance value will be 5 Mega ohms.

The test equipment for insulation testing will be furnished by Contractor.

Before making connections at the ends of each cable run, the insulation resistance test of each cable shall be made. Each conductor of a multicore cable shall be tested individually to each other conductor of the group and also to earth. If insulation

resistance test readings are found to be less than the specified minimum in any conductor, the entire cable shall be replaced and the new cable shall be installed/laid.

All switch gear shall be given an insulation resistance measurement test to ground after installation but before any wiring is energized. Insulation tests shall be made between open contacts of circuit breakers, switches and between each phase and earth.

If the insulation resistance of the circuit under test is less than that specified above the cause of the low reading shall be determined and removed. Corrective measures shall include dry out procedure by means of heaters of equipment is found to be contained measure. Where corrective measures have been necessary and the insulation resistance reading taken after the correction has been made it should satisfy the requirements specified herein. Repeated insulation resistance test shall be made twice and at least 12 hours apart. The maximum range for each reading on the 3 successive tests shall not exceed 12 hours apart and 20% of the average value. After all tests have been made successfully, the equipment shall be reconnected.

### **EARTH RESISTANCE TESTS**

Each resistance test shall be made by the Contractor on the earthing system, separating and reconnecting each earth connection as may be required by the Engineer Incharge. If it is indicated that soil treatment or other corrective measures are required to lower the ground resistance values, the Engineer Incharge will determine the extent of such corrective measures.

The electrical resistance of the ECC together with the resistance of the earthing lead measured from the connection with earth electrode to any other position in the completed installation shall not exceed one ohm.

Earth resistance test shall be performed as per Electrical Inspector's requirements. Where more than one earthing sets are installed, the earth resistance test between two sets shall be measured by means of Resistance Bridge Instrument. The earth resistance between two sets shall not exceed one ohm.

### **OPERATING TESTS**

Current load measurement shall be made on all electrical equipment.

The current reading shall be taken in each wire and in each neutral wire while the circuit or equipment is operating under actual load conditions. Clip-on ammeters may be used to take current readings.

All light fittings shall be tested electrically and mechanically to check whether they comply with the standard of specifications. Light fittings shall be tested so that when functioning properly no flickering is observed or choke noise is heard.

After any equipment has been tested, checked for operation etc, and is accepted by the Project Engineer's representative the Contractor shall be responsible for the proper protection of such equipment for assurance that subsequent testing of other equipment of systems do not disturb the completed work.

## **VISUAL INPECTION**

Visual Inspection to verify that the Electrical equipment has been correctly installed in accordance with the design with correctly rated protection devices and bonding that no visible damage exists.

**SECTION – E – 11**  
**DOCUMENTS TO BE SUBMITTED**

The contractor shall submit following documents at the time of bidding or as per Instruction of the Engineer.

1. Documents and certificate to be submitted for approval, including.
  - Information to be provided with the bid.
  - Document to be provided by the owner.
  - Documentation.
  
2. Warranty.
  
3. Packing and delivery.
  
4. Marking.
  
5. Testing, including :
  - Type tests.
  - Routine Tests.
  - Special test.
  
6. Technical data sheet
  
7. Maintenance and operation manual
  
8. Training Program

## **SECTION – E – 12**

### **LIST OF APPROVED MANUFACTURERS/SOURCES OF ELECTRICAL EQUIPMENT**

\* All Equipment shall be procured from Principal Authorized agents / distributors / resellers

The Bidder shall fill the name of only one manufacturer for each equipment/material on which the tender is based. He shall be bound to supply the equipment from the same manufacturer. In case, the Bidder gives names of more than one manufacturer against any equipment, the Engineer / Owner can ask the Bidder supply the equipment from any one of them.

At the evaluation stage if it is noted that any material offered by the bidder does not meet the specification requirements, the Engineer / Owner reserves the right to ask the bidder to replace his choice of equipment supplier meeting the required quality and specification requirement.

During the execution stage if the material from any supplier is found defective / substandard the Engineer / Owner reserves the right to ask the successful bidder to replace his choice of manufacturer / supplier for that particular equipment.

Any change in manufacturer / supplier shall only be entertained if there is sufficient reason that adhering to the original choice of manufacturer / supplier shall be detrimental to either the project quality or project timeline. Proper approval shall have to be sought for change in the choice manufacturer / supplier at least 1 month before the equipment is to be procured.

S/No	Equipment	Manufacturer/Supplier	Country of Origin
01	Transformer 11kV/0.4 kV	i. Siemens ii. Pak Electron Limited (PEL) iii. Transfopower	Pakistan
02	M.V Cables	i. Pakistan Cables ii. Newage Cables iii. Pioneer Cables	Pakistan
03	MV Cables Accessories (Jointing & Termination Kits)	i. 3M ii. Raychem	USA USA
04	Cable Glands, Lugs, Terminals and Accessories	i. Cembre ii. Hubbell / Hawke iii. Hensel	UK UK Germany
05	L.V Lighting Control Panel (LCP)	i. Schneider Electric ii. PEL iii. Hussain & Company iv. Taj Engineering v. Libra Engineering	Pakistan
06	LV Circuit Breakers	i. Schneider Electric ii. Terasaki iii. ABB iv. General Electric v. Legrand	France Japan Germany USA France
07	C.T, P.T's, Relays & instruments	i. Schneider Electric. ii. Siemens iii. General Electric iv. Revalco	Italy France Korea
08	Push Buttons, Switches, Etc.	i. Lovato ii. Socomec iii. Autonics iv. Legrand v. Maruyasa vi. Schneider Electric	Italy France Korea France Japan France

09	LV Cables and Wires / Earthing Cable	i. Pakistan Cables ii. Fast Cables iii. Pioneer Cables iv. Newage Cables v. Allied Cable	Pakistan
10	UPVC Conduits / Pipes and Accessories	i. Galco ii. Dadex iii. Jeddah Polymer iv. Civic	Pakistan
11	Street Light	i. Gewiss ii. G.E iii. Osram iv. E.A.E v. Philips	Italy USA Germany Turkey Netherland
12	Street Lighting Poles	i. Jamal Pipes ii. Farhan Mechanical Works iii. Bashir Pipe Industries iv. Al – Babtain v. Petit jean	Pakistan Pakistan  Pakistan Saudi Arabia France
13	Diesel Generator Fully imported. (Assembled in US, Europe or Japan) Diesel Generator ( Engine)	i. John Deere ii. Mitsubishi iii. Caterpillar iv. Cummins v. Volvo vi. Perkins	UK Japan USA UK EU UK
14	Diesel Generator ( Alternator)	iv. Caterpillar v. Mecc Alte vi. Stamford vii. Leroy Somer viii. Mitsubishi	USA Italy UK France Japan
15	Earthing equipments & Cu.	M/s. Erico M/s. Furse M/s. Wallis	USA UK UK