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**Project Management Unit
Municipal Service Delivery Program.
Government of Khyber Pakhtunkhwa**

Bidding Document

**Improvement/Rehabilitation of Water Supply System
in Malakand Division (Mingora Swat)**

Supply & Installation of 25 Nos. Pumping sets for Tubewells
(Package # 3)

Volume-II

March, 2020

**Project Management Unit (MSP)
Local Government, Election and Rural Development Government of Khyber Pakhtunkhwa
University Town Peshawar**

Municipal Services Program

Municipal Services Program

Improvement/Rehabilitation of Water Supply System in Malakand Division (Mingora Swat)

Supply & Installation of 25 Nos. Pumping sets for Tubewells
(Package # 3)

Tender Documents

Volume II

SPECIFICATIONS

TABLE OF CONTENTS

<u>S.#</u>	<u>DESCRIPTION</u>	<u>Page No</u>
<u>Electrical Works</u>		
Section – E 01	Basic Electrical Requirements	4
Section – E 02	Conduit System, Cable Tray, Cable Ladder and Trunking Installation	12
Section – E 03	Wire and Cable	19
Section – E 04	Mains & Sub-circuit Distribution	23
Section – E 05	Low Voltage Switchboards	27
Section – E 06	Luminaries and Accessories	42
Section – E 07	Wiring Devices	47
Section – E 08	Fire Alarm System	53
Section – E 09	Earthing System	57
Section – E 10	Lightning Protection System	64
Section – E 11	Testing, Commissioning, Inspections And Certifications	69
Section – E 12	Particular Specifications	79
<u>Mechanical Works</u>		
Section – M 01	Mechanical Specifications	90

ELECTRICAL WORKS

SECTION E 01**BASIC ELECTRICALREQUIREMENTS****1.01 Scope**

The work shall include furnishing all materials, labour, plant, and supporting services for the complete supply, installation, testing and commissioning of following system but not limited to:

- a) Interior lighting, fans & fixtures
- b) Small General Power
- c) LV distribution boards / Switchgear
- d) LV cables/ Bus tie duct
- e) Earthing System
- f) Cable Management for power & communications systems
- g) Voice/Data System
- h) Fire Alarm System
- i) Public Address System
- j) Testing and commissioning of the entire electrical system.

The Contractor shall be responsible for providing within his bid price any additional equipment and or make modifications in the electrical equipment/material to suit the requirement of the equipment offered by him for ensuring proper operation of the system as approved by the Consultant.

The Contractor shall ensure all necessary co-ordination with the works of other Contractor and shall be responsible for any loss or damage caused due to his fault or negligence, and shall rectify the same at his own cost.

All allied and small works and materials, even if not specifically mentioned in the specifications and BOQ but required for completeness of the job, shall be deemed to have been included in the contract/BOQ.

1.02 General

- a) Electrification work shall be carried out by a licensed Electrical Contractor, in conformity with the 17th Edition of the UK IEE “Regulations for Electrical Installations”, the “Electricity Act, 1910”, the “Electricity Rules, 1937”, in accordance with the requirements of the local Electric Inspector, the WAPDA, the Pakistan Telecommunications Company Ltd., & to the satisfaction of the Employer/ Consultant.
- b) It shall be the responsibility of the Contractor to serve notices on, submit documents to, and to have the installation passed by the relevant Authorities, and obtain all necessary approvals and sanctions at no extra cost to the Employer. Official fees for electrical inspections and approvals shall be paid by the owner at actual.
- c) The Contractor shall take care not to damage the existing structures, services and equipment during execution of work. If so done, he shall repair and make good all losses at his own cost.

The cost of any civil work (cutting, chasing, welding, plinths, foundations, excavation, back-filling, connecting, grouting, shoring, de-watering, making good, etc.) associated with any item of the electrical works shall be included in the quoted price for the electrical item.

- d) The Contractor shall take extreme care in maintaining proper supply where required to all working areas during the installation period, so there is no disruption in the Employer's working schedule. All the above shall be done at no extra cost.
- e) The Consultant/Owner will supply the required drawings, installation manuals, technical data, and instructions as received from the manufacturers of any Owner supplied equipment. However, the Contractor shall take full responsibility of technically correct handling, installation, testing and commissioning of the equipment, whether or not the manufacturer's instructions are made available to him with the delivered equipment.
- f) It shall be presumed that the spaces and access shown in the tender drawing are adequate and proper for the equipment to be supplied by the Contractor, unless so notified by the Contractor at the time of submission of the bid.

1.03 Electrical Service Connection

It shall be the Contractor's responsibility to file all applications and give all notices to the power supply authority (WAPDA) for provision of the electrical load required as a result of this work and to seek quotation for installation, furnishing & connection of the required electrical power complete in all respects, well in time so as not to delay the testing, commissioning and utilisation of the building. Official receipted expenses and costs shall be paid by the Owner at actuals.

All requirements of the WAPDA will be determined by the Contractor at an early stage, and any equipment provided by him will be deemed to be in line with the WAPDA's requirements. Space and access for WAPDA-related equipment shall be determined and defined by the Contractor at an early stage to facilitate construction of the sub-station spaces.

When the installation is complete, the Contractor shall intimate the power supply authority and make such tests as required by them to demonstrate conformance with the regulations prior to their connection to the installation. The extent of work specified represents the minimum requirements and includes energization of the building electrical loads. The extent of the work shall be extended as required to include, at no increase in cost to the Owner, the compliance & fulfilment of all requirements of the local power supply authority for an installation of this type.

1.04 Materials and Workmanship

All materials, equipment, accessories, fixtures & fittings shall be new of latest model and in accordance with specifications of the British Standards Institute, International Electrotechnical Commission and Pakistan Standards Institute. 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 & 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/Consultant before purchase or fabrication. Routine tests at the manufacturer's works shall be witnessed by the Employer, 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. For specialised systems (voice/data, fire-alarm), installation and commissioning shall be undertaken under the supervision of an engineer trained at the respective manufacturer's factory.

The Contractor shall provide "Danger Boards" on all panels and "Shock Charts" wherever required to comply with the requirements of Electricity Rules at no cost to Employer.

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.

1.05 Shop Drawings/As-Built Drawings

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

Checking of the Contractor's Shop Drawings by the Engineer, shall not relieve the Contractor of his responsibility for compliance with the design intent, co-ordination or with any other obligations and requirements under the Contract.

The Contractor shall allow in his Tender for providing:

Shop Drawing:

- 2 – Copies of shop drawing for preliminary checking by Consultant
- 4 – Copies of finally approved shop drawing for onward transmission

As-Built Drawing

- 2 – Copies of As-built drawing for preliminary checking by Consultant
- 4 – Copies of finally approved As-built drawing + reproducible drawing for onward transmission

All drawings prepared by suppliers, manufacturers and/or Contractors 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 & detailed manufacturer's shop drawings (including dimensional plans, elevations, section, line and wiring diagrams, foundation details, component characteristics and data, etc.) shall be got approved by the Employer/Consultant before purchase or fabrication.

1.06 Climatic Conditions

Equipment and materials supplied shall withstand, under all conditions of continuous operation and without developing any defects, the following environmental conditions:

Region	Max. Temp. °C	Min. Temp. °C	Max. Relative Humidity %	Altitude (above Sea Level) m
Peshawar	40	4	100	359

1.07 Equipment Protection

Unless otherwise noted, all equipment supplied shall conform, as a minimum, to the following protection classes, in accordance with BS 5490:

Indoor	IP 20/ IP 40
Outdoor	IP 54/IP 65

With the exception of material specified to be hot-dip galvanised (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 damaged metal work shall be given another coat of paint. Painting of steel conduits shall be to BS 1710 for colour coding purposes.

All metal-work located outside buildings shall be protected against corrosion by a hot-dip galvanised coating, to BS 729, before installation.

1.08 Standards and Typical Designs

The specification either cites or implies British/IEC Standards. Other comparable European and U.S. Standards and typical designs are acceptable, providing that they in no way detract from the quality, safety, operability, or durability of the equipment and material furnished. However, when other standards or typical designs other than those cited or implied are offered by the Contractor, he shall set these forth in detail in his proposal.

1.09 Abbreviation for Standards

The standards, codes of practice and recommendations of the following Societies or institutions have either been used in the specification and or cited here as a general level of quality for equipment, material and workmanship.

Abbreviations for international institutions are given below:

International Electrotechnical Commission	IEC
European Committee for Standardisation	CEN
International Standards Organisation	ISO
Underwriters Laboratories	UL

Abbreviations for some European/US societies & standards institutions are as follows:

Association Francaise de Normalisation, France	AFN
British Standard Institution, UK	BSI
Deutsches Institut fur Normung, Germany	DIN
Institution of Electrical Engineers, UK	IEE
Institute of Electrical & Electronic Engineers	IEEE
Chartered Institution of Building Services Engineers, UK	CIBSE

Electronic Industries Association, USA	EIA
Telecommunication Industries Association, USA	TIA
National Fire Protection Association	NFPA
American National Standard Institute	ANSI
Building Industry Consulting Services International, USA	BICSI
National Electric Codes	NEC

Abbreviations for Pakistani institutions are given below:

Pakistan Standards Institution	PSI
Building Energy Code of Pakistan	BECP
Building Control Act and Regulations	-
Water and Power Development Authority	WAPD
	A
Pakistan Telecommunications Company Ltd	PTCL
Building Control Act and Regulations	
Building Energy Code of Pakistan	
Electrical Act, 1910	
Electrical Rules, 1937	

1.10 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 earth loop resistance tests
- c) Megger tests, on switchgear and cables
- 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) All routine tests on equipment shall be performed at the manufacturer's works in the presence of the Consultant or his representative prior to delivery of equipment. Test results and certificate shall be provided in triplicate, to the Consultants/Owner.
- g) Operation, testing and commissioning of the entire installation.
- h) Copies of final test reports and values shall be provided to the Consultant/Employer in triplicate.

1.11 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 20% overheads, profit, etc.) with the bills.

1.12 Safety Program

- a) The Contractor shall strictly follow at his own cost the Safety Programme outlined below and such additional measures as the Engineer or Engineer's representative may determine to be reasonably necessary.
 - i) Prior to commencement of work the successful Contractor shall submit safety programme for discussion with the Employer and the Engineer.
 - ii) The Contractor shall prepare a plan of the Works' Site to assure that storage areas for materials and equipment are located on the project/work site for maximum efficiency. This plan will be subject to the approval of the Engineer.
 - iii) Activities between different operations and different crafts will be co-ordinated.
 - iv) The Contractor shall lay out and provide an efficient access system with information and directional signs posted as necessary.
 - v) All employees will be instructed on safe work method.
 - vi) The Contractor shall advise all his supervisory staff of their responsibility for the prevention of injury to persons or damage to property or equipment in their respective areas of supervision.
 - vii) Safety will be included in all job planning. This will include providing safe construction equipment and vehicles, protective equipment necessary for protection of workmen, and establishing methods for safe operation.
 - viii) Good housekeeping will be maintained at all times.
 - ix) Scaffolds, ladders, ramp", runways etc. will be constructed properly and maintained in safe conditions.
 - x) Ample fire protection will be provided and fire hazards guarded, by the Contractor.
 - xi) Adequate lighting, ventilation etc. will be provided as necessary, by the Contractor.
 - xii) Equipment will be properly and regularly inspected and maintained by the Contractor to the satisfaction of the Engineer.
 - xiii) The Contractor will assign to his employees only such duties as are within their physical and mental capabilities.
 - xiv) The Contractor will hold monthly meetings with his supervisory staff and the man incharge at the lower level will hold safety meetings of 10 to 15 minutes with his crew each week.
 - xv) First Aid facilities will be provided at job sites, the services of doctors and hospitals made available, and all supervisors instructed in handling of injured employees.

- xvi) Adequate toilet facilities will be provided, maintained in a hygienic condition and their use enforced by the Contractor.
- b) Accident reports will be furnished to the Engineer for onward transmission to the Employer within 2 days of the reported accident.
Copies of the safety programme will be supplied by the Contractor to the Engineer and will be promptly posted in all offices in use of projects/works under this Contract.
- c) At all construction sites the following instructions shall be followed:
- ◆ availability of safety (hard) hats, which should be worn by anyone visiting or working within the designated work area
 - ◆ controlled entry to the designated work area
 - ◆ proper distribution of temporary electric power (use of RCDs/ELCBs, switch gear, cabling, socket outlets)
 - ◆ proper guarding of shafts, stairs and floor edges up, to a height of 42".
 - ◆ proper access stairs and ladders with handrails
 - ◆ properly demarcated passageways, which are kept clear of materials, equipment, and rubbish
 - ◆ daily cleaning of debris and rubbish from the site
 - ◆ adequate temporary lighting
 - ◆ proper housekeeping to reduce slipping and tripping hazards.
 - ◆ proper protection to pedestrians and adjoining buildings
 - ◆ Contractor's All-risk Insurance policy to be in place.
- d) To ensure safety of all people on the Site during the construction process, including Contractors' personnel and Employer's representatives, the following procedures shall be adopted by all Contractors for the use of temporary electricity supply.
- i) Work shall generally be carried out in accordance with 17th Edition of UK IEE Wiring Regulations, BS CP 1017 "Distribution of Electricity on Building Sites", and the Pakistan "Electricity Rules, 1937" all legal formalities of the Electric Inspector's office shall be complied with.
 - ii) Construction of cables used shall be as follows:
 - to fixed distribution boards and fixed equipment, PVC/SWA/PVC, to BS 6346.
 - to moveable plant, flexible armoured cables, to BS 6116.
 - to welding electrode-holders, flexible cables to BS 638.
 - to portable tools and hand-lamps, flexible cords to BS 6500
 - iii) Installation of cables shall be as follows:

- outdoors, directly buried at least 500mm below grade, with tile covers and cable markers (at minimum 10 meter intervals and at bends), and in RCC pipe at road/traffic crossings.
 - indoors, clipped to the surface at least 3000mm above floor/ground level.
Strain relief shall be provided at termination of all cables at equipment, plugs, etc..
- iv) Double earthing, with stranded copper conductors, shall be used to establish a TNS system. No separate earthing electrodes are required at each location.
- v) A main distribution board, to BS 4363, of totally enclosed sheet-steel construction (IP 54) shall be provided, with 30mA trip residual current device(s) for the earth-leakage protection of circuits. Short-circuit and overload protection shall be provided by circuit-breakers of the appropriate rupturing capacity.
- vi) Plugs, sockets, and accessories of a robust, unbreakable construction, to BS 4343, shall be used for all equipment. Portable tools, to BS 2769, shall preferably be of double-insulated construction and be operated at 230V.
- vii) A layout drawing of the proposed temporary installation with schematics, cable sizes and routes, earth conductors, and protection details shall be had approved from the Employer. After installation, test results (insulation resistance, earth-loop impedance, etc.) shall be submitted, re-testing shall be done every three months.

SECTION E 02**CONDUIT SYSTEM, CABLE TRAY, CABLE LADDER AND TRUNKING INSTALLATION****1.0 GENERAL****1.01 WORK DESCRIPTION**

- A. This section describes the supply and installation of wiring facilities systems include conduits, cable trays, cable ladder and trunking system, c/w associated fittings and accessories.
- B. All cables run above the suspended false ceiling, concealed in walls, columns, or on surface shall be supported by conduits, cable tray, trunking or cable ladder system. No free slinging cable is allowed.
- C. The cable routes as shown in the drawings shall be used as a guide only. Prior to the installation, the cable routes shall be coordinated with other services. Uncoordinated and inaccessible routes after other services are installed, shall be relocated at the expense of the Contractor.
- D. All conduits, trunkings, cable trays and cable ladders shall be earthed in accordance to BS7671 & BS7430.
- E. All Telephone and Data Cabling shall be contained within cable containment as specified in this specification.

1.02 STANDARDS

- A. The complete wiring facilities system shall be manufactured, supplied, installed and tested in accordance with the latest revision of the following standards and the appropriate BS/IEC include:
 - 1. Steel Conduit and Fitting Accessories BS4568 & BS731
 - 2. PVC Conduit and Fitting Accessories BS6099 & BS4607
 - 3. Cable Tray BS729
 - 4. Cable Ladder BS729
 - 5. Cable Trunking BS4678
- B. The complete wiring facilities system shall also conform to the requirements of all relevant local codes, as applicable, together with the additional requirements referred to in this Specification and Drawings, whichever is the more stringent and acceptable to the Engineer.
- C. In the adoption of standards and requirements, the Contractor shall take the following precedence:
 - 1. Engineer's decision;
 - 2. Local codes of practice;
 - 3. Drawings;
 - 4. Specification;
 - 5. International standards and requirements

1.03 SUBMISSIONS

-
- A. All technical submissions shall be approved by the Engineer prior to the respective stages of construction.
1. Routing of installation
 2. Sample with proprietary factory-made accessories, elbows, risers, reducers, tees, crosses, etc.

2.0 PRODUCTS

2.01 STEEL CONDUIT AND ACCESSORIES

A. Steel Conduit

1. Conduits shall be of heavy gauge steel conforming to British Standard. They shall be solid drawn or seamed by welding. Both ends of the conduit shall be screwed.
2. Conduits shall show no appreciable unevenness and their interior and ends shall be free from burrs, fins and the like which may cause damage to cables. Removal of any rough internal edges shall be made by a reamer rather than any tools that comes to hand.
3. Conduits used for the project shall be galvanized to Class 4 type of BS 4568: 1970 and be approved reputable manufacturer. Adequate protection against corrosion shall be applied to both conduit interior and exterior.
4. Flexible conduits used for equipment that subject to vibration such as pump, motor, etc. shall be of mild steel complying with BS 731:Part 1:1952. All flexible conduits shall be PVC covered. Low smoke zero halogen materials covered for installation within false ceiling.

B. Fittings

1. Samples of conduit fittings shall be submitted for approval prior to installation.
2. Fittings shall be those intended for use with screwed conduits and shall comply with BS 4568:Part 2:1970. However, bends, elbows and tees shall not be installed.
3. Boxes and cover plates that are installed outdoors shall have fixing lugs exterior to the box so that fixing screws do not enter the box interior.
4. Adaptors used with flexible conduits shall conform to BS 731:Part 1:1952.

C. Circular Boxes

1. Circular boxes shall be of malleable cast iron, galvanized and of standard pattern with spout(s). When used for connecting lengths of conduits, circular boxes shall be provided with cover plates of similar make that are complete with brass fixing screws.

D. Rectangular Boxes

1. Rectangular boxes (adaptable boxes) shall be of mild steel not less than 2.4 mm gauge and galvanized. When used as junction boxes, lids of the same gauge with brass fixing screws shall be used.

E. Boxes for Accessories

1. Boxes for accessories shall be suitable for surface mounting or recessed mounting according to the requirements. Surface mounted boxes and accessories shall be metal clad pattern. Recessed boxes and accessories shall be complete with insulated moulded type cover plates.

F. Covers

1. All covers for boxes, etc shall be made of galvanized steel of 1.2 mm thickness.

2.02 PVC CONDUIT AND ACCESSORIES

A. PVC Conduit

1. Conduits shall conform to BS 6099: Part 1 and shall be heavy gauge of wall thickness of 1.9 mm rigid tubes which are unscrewed without coupling and with plain ends. All conduits used shall not be less than 20 mm diameter.
2. PVC conduit mounted outside building will not be accepted. PVC conduits shall not be used where liable to mechanical damage.
3. PVC conduit shall be used for all concealed installation.
4. PVC conduit shall not be filled more than 50% of its capacity.

B. PVC Conduit Accessories

1. Accessories used for conduit wiring shall be of an approved type complying to BS 4607.
2. All accessories used shall be of standard white or black colour, identical to conduit used.
3. Plain conduits should be jointed by slip type of couplers with manufacturer's standard sealing cement.
4. All conduit entries to outlet boxes, trunking and switchgear are to be made with adaptors female thread and male bushes screwed.
5. PVC-switch and socket boxes with round knockouts are to be used. The colours of these boxes and the conduits shall be the same.
6. Standard PVC circular junction boxes are to be used with conduits for intersection, Tee-junction, angle-junction and terminal. For the drawing-in of cables, standard circular through boxes shall be used.
7. Samples of accessories shall be submitted for approval prior to installation.
8. All jointing of PVC conduits shall be by means of adhesive jointing. Adequate expansion joints shall be allowed to take up the expansion of PVC conduits.

2.03 CONDUIT INSTALLATION

The whole conduit system shall be installed to comply fully with BS 7671.

A. Layout

1. The conduit layout and conduit routes shall be submitted for approval. Allowance for adjustments due to site conditions shall be provided with no extra cost.
2. Conduit routes shall be chosen for easy, straight runs with a minimum of bends and crossings. Generally they shall follow the structure of building, running at right angles or in parallel to floors and ceilings. Conduits shall be kept within 300 mm of floors and ceilings when running parallel to them.
3. Outlet boxes for housing accessories shall be used as draw boxes. The total number of draw boxes shall be kept to a minimum and shall be provided so that conduit runs do not exceed 12 m or have more than two right angle bends.
4. All conduits shall be kept clear of gas and water pipes. In particular, conduits shall be at least 150 mm away from gas pipes. Where proximity to these pipes is unavoidable, they shall be effectually segregated e.g. using rubber or other insulating material to prevent appreciable voltage differences at possible points of contact. Segregation from extra low voltage circuits and telecommunication circuits shall also

apply unless these are wired to the same voltage requirements as lighting and power circuits.

5. Conduits from different distribution boards shall not be connected to the same junction box. Each run of conduit shall be assembled complete with draw-in-wires.

B. Joints And Terminations

1. Electrical and mechanical continuity shall be maintained throughout all conduit joints and terminations. Conduit threads shall be thoroughly cleaned and the conduits tightly screwed. The conduit system shall be watertight after installation.
2. Conduits shall be connected using coupler or via boxes. With a coupler, the ends of the conduit shall be butted close together and the running coupler is screwed tightly on and tightened by a locknut.
3. Conduits terminating into boxes provided with spouts shall be threaded so that there are no exposed threads. For boxes with no spouts, the termination shall be made using a brass bush and a coupler. The conduit is pushed through the knockout or drilled entry and the bush is screwed tightly onto its end. The coupler is screwed to butt firmly against the exterior wall of the box.
4. Where conduits are not jointed or terminated in boxes, they shall be terminated in a screwed brass bush.
5. In all joints and terminations, conduit threads shall not be exposed. Where this cannot be avoided as in a running coupler, the exposed threads shall be coated with red lead paint to seal against the ingress of water.

C. Bends

1. Conduits shall only be bent cold with an approved type of bending block or bending machine, without altering the dimensions of their sections.
2. All conduit bends shall be such as to permit compliance to the requirements for bends in cables to as stated in the BS 7671.
3. Bends shall be made with as large a radius as the position of the conduit within the building permits. Where the bend is more than 90 degree, circular or rectangular junction boxes are to be used for connecting conduits.

D. Cabling

1. The conduit system must be completely installed and free of obstructions and sharp corners before any cables are drawn in. Conduits shall be thoroughly swabbed to remove moisture and dirt immediately prior to the drawing in of cables.
2. Cables shall be drawn without crossing each other and shall not be pulled against the walls of the draw boxes. Slack cables shall left in all draw boxes.
3. Cables shall be continuous throughout conduit lengths and no joints are permitted. There shall be no kink in cables, neither any cut, abrasion or chink in the cable insulation.
4. The same conduit shall carry the lead and return conductors bunched together. However, the same conduit shall not house cables from different distribution boards.
5. Cables for power and lighting circuits and extra low voltage systems shall not be drawn into the same conduit. Lighting and power final circuits shall be run in separate conduits except, where an adaptable box is employed as final distribution point, a number of final circuits may be grouped together in larger conduits between the distribution board and the adaptable box provided that all final circuits in one conduit are of the same phase. In the case of three phase circuits, all three phases including neutral, if any, shall be drawn into the same conduit.
6. Conduits shall not constitute the earth continuity path for the electrical circuit. A separate circuit protective conductor shall be installed within the conduit. The whole conduit system shall be effectively earthed.

7. Flexible conduits shall also have a separate earthing conductor installed within the tubing and connected at conduit ends. Flexible conduits in general shall not be used for more than 3m length.

E. Access And Drainage

1. The conduit system shall be rewirable, that is, draw boxes must be accessible for the purpose. Where boxes are concealed, their covers shall be flushed with the finished surface.
2. The need for accessibility notwithstanding, the conduit system shall be protected against the ingress of water and impurities. When installed, conduits shall be kept dry and free of debris with approved pipe plugs or caps. Such plugging is especially essential prior to pouring concrete for concealed installation. As for boxes, they shall be covered by steel plates prior to concreting.
3. When installed outdoor, and in situations liable to condensation of moisture, conduits shall be arranged to be self draining, so that water may drain to low points which are fitted with a drain plug. Conduits laid under concrete floors shall have watertight floor-traps of approved detail for access of these drainage points.
4. Conduits run on surfaces other than structural steel members shall be secured using galvanized space bar saddles and brass fixing screws. Spacing of saddles shall not exceed 1.2 m for conduit sizes up to and including 25 mm and 1.8 m for sizes 32 mm and above.
5. Conduits run on structural steel shall be secured using girder clips or an approved clamp. These conduits and those run in the vicinity of structural steel shall be bonded to the steelwork using an efficient and permanent metallic connection. The conduits shall not in any way be under mechanical stress.
6. All conduit boxes except loop-in patterns shall be fixed direct to the building structure in addition to the support provided by the conduits.
7. Conduits shall be painted with an approved paint to blend with visual environment. A zinc rich undercoat shall be provided before painting the final coat.

2.04 CABLE TRAY

- A. Cable tray shall be of perforated type and constructed a minimum 1.6 mm hot dipped galvanized mild steel with powder coated paint for outdoor damp condition, and epoxy coated electro-galvanized mild steel for indoor installation. All cable trays shall be installed in a straight run parallel to walls where possible.
- B. Cable trays shall be supported by electro-galvanized 'U' channel with galvanized threaded rod for indoor suspended tray and hot-dipped galvanized for area subject to weather.
- C. All hangers shall be installed at 1 meter intervals and shall be primed and painted to match with the surrounding building finish approved by the Engineer.
- D. For cable tray that are exposed to the weather, a hot-dip galvanized covers of 1.5mm gauge steel, flush fixing type with gasket, shall be installed on top of the tray.
- E. Copper earth link bar shall be fixed at every joint of the cable tray run.

2.05 CABLE LADDER

- A. All cable ladders and accessories installed indoors shall be heavy-duty epoxy coated electro-galvanized mild steel type. All cable ladders installed outdoors shall be heavy-duty hot dipped galvanized hot rolled mild steel to BS 729. Thickness of the mild steel shall not be less than 2 mm.

- B. Cable ladder shall have a 150 mm high longitudinal side member for ladders width of 800 mm or above and 120 mm high longitudinal side member for ladder width less than 800 mm.
- C. The rungs shall be at least 50 mm wide, with slots of 25 mm x 10 mm at 25 mm intervals covering the length of the rungs. The rungs shall be space at 300 mm apart along straight lengths of the ladder.
- D. All nuts, bolts and washers for clips and brackets shall be zinc plated. Each cable ladder shall be in standard manufacturers' length and supplied complete with coupling sets consisting of fishplates, spined bolts, nuts and locking washers.
- E. The complete cable ladder installation shall be provided with all necessary proprietary factory-made elbows, risers, reducers, tees, crosses, drop-outs, etc. and any site fabricated items will not be permitted.
- F. Separate flexible earth continuity connectors of at least 16mm² copper jumpers shall be installed between the ladder sections.
- G. All cables ladders shall be supported from the ceiling concrete slab, steel structures or sidewalls using a frame system similar to UNISTRUT, with overhead hangers, support channels, hanger rods or angle brackets, beam clams and ceiling brackets.
- H. Fixings and supports shall be installed at regular intervals not exceeding 1000 mm and 150 mm from all bends, tees, inter-sections and risers.
- I. When cable ladder is refined to install across structure expansion joints, the ladder shall be in two sections between supports installed on either side of the expansion joint.
- J. The ladder sections shall than be jointed with expansion joint fishplates, bolts, nuts and washers installed in elongated holes permitting a lengthwise movement of 25 mm from the initial fastening position.
- K. For cable ladder that are exposed to the weather, a hot-dip galvanized covers of 1.5mm gauge steel, flush fixing type with gasket, shall be installed on top of the ladder.
- L. Copper earth link bar shall be fixed at every joint of the cable ladder run.

2.06 CABLES TRUNKING

- A. Cable trunking shall be manufactured from 1.6 mm minimum electro-galvanized mild sheet steel to BS4678 finished in oven-baked electrostatically coated epoxy powder coating with colour to the Engineer's choice.
- B. All trunking shall have removable lids extending over their entire lengths. Lids shall be fixed at interval not exceeding 1 meter by means of brass steel screws which and protected against corrosion by a finish of zinc coating or equivalent to zinc coating.
- C. Factory-made bends, joints, elbow, riser, tee, reducer and accessories with same material shall be provided throughout the installation for trunking.

- D. Trunking space factor shall be in compliance with BS7671.
- E. Copper earth link bar shall be fixed at every joint of the cable trunking run.

SECTION E 03**WIRE AND CABLE****1.0 General****1.01 Work Description**

- A. This section specifies the supply and installation of LV power cables. Each type of cables specified shall have been certified that it has been manufactured to the appropriate BS and any local agency.
- B. The routing and the minimum rated current carrying capacity of the LV power cables shall be as indicated on the Drawings. The Contractor shall consider the manufacturer data and engineering the cable sizing to ensure it suit the conditions, via grouping, ambient temperature etc., and for making any necessary adjustment to the Engineer's approval.
- C. The current carrying capacities and voltage drop of cables shall be in accordance with the latest edition of BS7671.
- D. All LV cables for normal power/control circuits within buildings shall be copper conductor with PVC insulated and PVC sheathed, denoted as PVC/PVC cable or copper conductor with PVC insulated, denoted as PVC cable as specified.
- E. Cablings in service ducts, open trenches, direct-laid underground in soil shall be by means of armoured cables. Non-armoured cables shall be laid in conduits, trunkings or tray/ladder for mechanical protection.

1.02 Standards

- A. Complete cabling shall be manufactured and constructed in accordance with the latest revision of the following standards and the appropriate BS/IEC :
 - 1. BS1442 - Galvanized mild steel wire for armouring cables
 - 2. BS4066 - Test on electric cables under fire conditions
 - 3. BS4109 - Copper for electrical purposes and insulated cables and flexible cords
 - 4. BS4579 - Performance of mechanical and compression joints in electric cable and wire connectors
 - 5. BS5467 - Technical Specification for armoured cables with thermosetting insulation for electricity supply
 - 6. BS5468 - Technical Specification for XLPE insulation of electric cables
 - 7. BS6004 - Technical Specification for PVC insulated cables (non-armoured) for electric power and lighting
 - 8. BS6081 - Technical Specification for termination for mineral insulated cables
 - 9. BS6121 - Mechanical cable gland for elastomer and plastic insulated cables
 - 10. BS6141 - Technical Specification for insulated cables and flexible cords for use in high temperature zones
 - 11. BS6207 - Mineral-insulated cables
 - 12. BS6346 - Technical Specification for PVC insulated armoured cables for electricity supply
 - 13. BS6387 - Technical Specification for performance requirements for cables required to maintain circuit integrity under fire conditions
 - 14. BS6425 - Test methods for gases evolved during combustion of materials from electric cables
 - 15. BS6724 - Technical Specification for armoured cables for electricity supply having

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- thermosetting insulation with low emission of smoke and corrosive gases when affected by fire
16. BS6746 - Specification for PVC insulation and sheath of electric cables
 17. BS7211 - Specification for thermosetting insulated cable (non-armoured) for electric power and lighting with low emission of smoke and corrosive gases when affected by fire
- B. The manufacturing of the cable shall also conform to the requirements of all relevant local codes, as applicable, together with the additional requirements referred to in this Specification and Drawings, whichever is the more stringent and acceptable to the Engineer.
- C. In the adoption of standards and requirements, the Contractor shall take the following precedence:
1. Engineer's decision;
 2. Local codes of practice;
 3. Drawings;
 4. Specification;
 5. International standards and requirements.

1.03 Submission

- A. All technical submissions shall be approved by the Engineer prior to the respective stages of construction.
- B. As a minimum requirement, the submission shall include the following:
1. Equipment submission with manufacturer's data
 2. Sample submission
 3. Shop Drawings of the cable routings showing the co-ordinated routing of cables, arrangement on cable trays, methods of fixing of cable trays and cables, etc. All conduits including concealed conduit routing drawings shall also be included
 4. Cable test reports.
 5. Builder's works requirement
 6. Cable schedule indicate the following data include:
 - a. Cable code and type and installation method
 - b. Cable feed from and serve to
 - c. Cable route length and voltage drop
 - d. Cable capacity and
 - e. Upstream protection breaker rating
 The cable schedule shall be prepared in according to the cable manufacturer's data.

2.0 Product

2.01 LV Cables

- A. PVC Cables
1. PVC cables shall be of 450/750V grade complying with BS 6004, copper core and PVC insulated.
 2. Conductors shall be plain annealed copper conductors complying with BS 6360.
 3. PVC cables shall only be used for final power circuits and control circuits, installed in conduits or trunkings, unless otherwise specified.

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4. The insulation shall be PVC type T11 complying with BS 6746, and flame retardant complying with BS 4066.
 5. Colour coding of the insulation shall be as follows:-
 - a. Phase : red, yellow, blue
 - b. Neutral : black
 - c. Earth : green and yellow
 - d. Control : white

B. PVC/SWA/PVC Cable

1. Cables shall be 600/1000V grade complying with BS 6346, copper core, PVC insulated, extruded PVC bedded, steel wire armoured and PVC sheathed.
2. Conductors shall be high conductivity stranded copper conductors complying with BS 6360, each conductor core shall be of the same cross-sectional area.
3. The insulation of cores shall be PVC type T11 complying with BS 6746.
4. The bedding shall be an extruded layer of type TM1 compound complying with the requirements of BS 6746.
5. Each core of the cable shall be identified by the appropriate colour as specified in BS 6346 throughout the whole of the insulation.
6. Wire armour shall consist of a single layer of galvanized steel wire of sizes as shown in the appropriate table in BS 6346 and comply with BS 1442.
7. The oversheath of the cables shall be an extruded layer of black PVC complying with the requirements of BS 6746 type TM1 compound and shall comply with the requirements of BS 4066 for flame retardance. The PVC material shall contain approved anti-termite additives.

D. XLPE/PVC CABLE

1. Cable shall be 600/1000V grade complying with IEC 502, copper core, cross-linked polyethylene (XLPE) insulated and PVC sheathed.
2. The XLPE insulation shall comply with BS 5467 and IEC 502.

E. XLPE/SWA/PVC CABLE

1. Cables shall be 600/1000V grade complying with BS 5467, copper core, cross-linked polyethylene insulated, extruded PVC bedded, steel wire armoured and PVC sheathed.
2. Conductors shall be high conductivity, stranded conductors complying with BS 6360.
3. Each conductor core shall be of the same cross-sectional area.
4. The insulation of cores shall be cross-linked polyethylene complying with relevant BS 5467.
5. The other specifications on bedding, colouring, armouring and oversheathing shall be the same as those for PVC/SWA/PVC cable.

F. FLEXIBLE CORD

1. Flexible cord shall comply with BS6007, PVC insulated with flame retardant white circular PVC oversheath to BS 6500 at 450/750V grade.
2. Flexible cord shall be multi-strand copper conductor insulated by vulcanized rubber, PVC, butyl rubber, ethylene propylene rubber (epv), silicon rubber or glass fiber. Cord shall be twin or three core with colour code brown for line, blue for neutral and green/yellow for earth complete with PVC or CSP (chlorosulphorated polythene) sheath.
3. Cord shall have cross-section area of not less than 0.75 sq. mm and shall be held firmly by cord grips provided in plugs.
4. Cords shall be used for pendant fixtures, portable lamps, portable appliances and stationary equipment. Cord shall not be permanently fastened to building surfaces and shall not pass through holes in wall, ceiling, floor, door-way and window.

G. CABLE GLANDS AND ACCESSORIES

1. For Armoured and Non-Armoured Cables
 - a. All cable glands shall be manufactured and tested to the requirements of BS 6121 and the relevant standard requirements.
 - b. All cable glands shall be manufactured from unplated brass complying with the requirements of BS 2874 and the relevant standard requirements.
 - c. Cable glands for armoured cables shall be accurately machined and have water-tights seals between outer sheath and gland, and between inner sheath and thread component, with electric bond for metallic inner sheath. The brass gland nut shall incorporate a cone-grip armour clamp which shall be manufacturer to ensure that each armour wire contributes equally to the conductance of the bonding connection. Cable glands for non-armoured cables shall be accurately machined and have water-tight seals on outer and inner sheath.
 - d. Each cable gland shall be supplied with a brass gland locknut, plain brass slip-on earth tag and flame retardant and termite repellent PVC outer gland shroud. The earth tag shall be flat circular ring type and placed between the gland and the apparatus into which it is screwed to ensure metal to metal contact between equipment/earth tag and gland. The thread engagement shall not be reduced to below the limits as specified in BS 4683 or BS 5501: Part 5 where appropriate. The PVC shroud shall totally enclose the gland body and form an effective seal down onto the cable's sheathing overall.
 - e. The body of cable glands shall be stamped with identification for the size, type and manufacturer.
 - f. For cables which are protected by ACBs or MCCBs, an integrally cast earth lug shall be provided at the entry portion of cable gland for armor clamp. The lug shall be complete with zinc passivated bolt for earthing the armour to the main earth system at the supply end.
 - g. All cable glands shall have the same IP rating as that of the switchboard or equipment to ensure the water proof integrity of the switchboard and equipment enclosure.

SECTION E 04**MAINS & SUB-CIRCUIT DISTRIBUTION****1.0 General****1.01 Work Description**

- A. Mains and sub-circuit distribution cabling of the LV System shall be as shown on the Drawings and as specified hereinafter.
- B. All mains and sub-circuit cables shall be in conduits, trunking, cable trays and ladders as appropriate. Armoured cables shall be used for all circuits in open ground in trenches or on open trays and ladders. All the mains, sub-mains and final sub-circuits shall include insulated earthing conductor sized in accordance with BS7671.
- C. The current carrying capacities and voltage drops of cables shall be in accordance with BS7671, with ratings adjusted to suit local conditions.
- D. Cable joint is not acceptable for all cable installation.

1.02 Submissions

- A. All technical submissions shall be approved by the Engineer prior to the respective stages of construction.
 - 1. Detailed schedule of cables and manufacturer's data, Manufacturer's type test certificates and testing documents shall be submitted for inspection. Detail requirement of cable schedule as specified in Section 2, Wire and cables;
 - 2. Calculations of voltage drop of cables;
 - 3. Calculations of the prospective short circuit current;
 - 4. Co-ordinated drawings showing all cable routings;
 - 5. Builder's works requirement;
 - 6. Detailed control wiring diagram.

2.0 Cable Installation**2.01 General**

- A. Cables shall be delivered on robust cable drums with cable ends treated to form an effective seal. When a cable is cut from a drum, the cable and the end left on the drum shall be immediately sealed in approved manner to prevent the ingress of moisture.
- B. Cables shall be installed along the routes as indicated on the Specification and Drawings and shall be agreed in detail with the Engineer before any work is commenced. There is no cost adjustment to any routing of the cables as required to suit the installation and subject to site co-ordination.
- C. All necessary precautions shall be taken to prevent damage to cables during installation.
- D. Where cables are installed in situations where works by M&E Services are still incomplete, all reasonable precautions shall be taken to protect the cables against damages arising from the execution of such other works.

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- E. Cable laying shall be carried out by means of normal hand running off the cable drum. Roller guides shall be used all through and be drawn through by hands. No cable winches shall be employed.
 - F. Cable entries into buildings shall be hermetically sealed with an appropriate fire, heat and water-resistant, non-ageing, flexible material.
 - G. Cables shall be adequately protected against all risk of mechanical damage to which they may be liable in normal conditions of services.
 - H. Cables shall be installed in accordance with BS7671. In particular, the internal radius of every bend in a cable shall be such that as not to cause damage to the cable and not less than the appropriate value stated in BS7671.
 - I. Except for cables laid in ducts, all cables as specified herein shall run on cable trays/cable ladder, vertically and horizontally, and properly fixed in the prescribed manner. Where cables are laid on cable trays/cable ladder in the horizontal directions, nylon cable ties shall be used. Where cables are installed in the vertical direction, approved clips and saddles shall be used. The spacing of cable fixings shall be in accordance with BS7671.
 - J. Where three-phase power is run in single core cables, the cables shall be grouped in a trefoil formation and spaced from other cables. The relative position of the single-core cables of the trefoil group shall be changed through 120° at approximately one-third and again at two-thirds point of the entire cable route.
 - K. Not more than one circuit of single core cables or one multi-core cable shall be grouped together. The spacing between groups of single core cables or multi-core cables shall not be less than twice the diameter of the largest cable in the adjacent group of cables.
 - L. Where cables pass through structural elements such as floors and walls, the opening made shall be sealed with approved fire-resistant material of not less than two (2) hours fire rating or not less than the fire rating of the slab/wall to prevent the spread of fire.
 - M. Where cables pass through expansion joints, the cables shall be formed into a loop which shall be of such size that any movement in the joint shall not stress the cables.

2.02 Final Sub-Circuit PVC Cable Installation

- A. In general, cables are to be run in zinc coated trunking to BS 4678; Part 1 or galvanized steel conduit.
- B. Unless otherwise in plant rooms, within false ceiling and boxed up riser, all final circuit wiring shall be in concealed conduit in concrete slab, wall, column, etc.
- C. Cables in trunking shall be bunched in approved cable tie.
- D. Trunking shall be properly sized to conform to IEE Regulations with minimum space factor of 45%.
- E. BS Standard or relevant other Standards, name of the manufacturer, the voltage grade and the relevant BS number shall be printed on the outer sheathed insulation of the cables.
- F. Cables for 3 phase, 4 wire system shall be colour coded – red, yellow, blue for phases, black for neutral and green/yellow for earth.
- G. Minimum size of cable shall be 1.5mm^2 for lighting, 2.5mm^2 for power and 2.5mm^2 for earth continuity subject to a maximum volt drop of 2.5% of the nominal voltage.
- H. The cable size shall be selected to ensure that it has adequate current carrying capacity and that the voltage drop at the apparatus supplied does not exceed the approved limit. Derating of cables shall also be taken into account for adverse conditions.
- I. Connection of fixtures shall be by the “loop-in & loop-out” method.

2.03 Non-Armoured Mains & Sub-Mains Cable Installation

- A. In general, the cables shall be installed on cable trays or ladders. They shall be installed to an acceptable way conforming to IEE Regulations to prevent losses in cables and performance of the current carrying capacity.
- B. Proper labeling shall be installed at every 6 m interval.
- C. Avoiding of overlapping of cable is necessary.
- D. A three phase circuit cables shall be installed on the same tray.
- E. The cables shall be terminated in suitably tinned copper compression connectors.
- F. Cables shall be routed at high level on proprietary make horizontal cable trays or cable ladders (for large cables) and support systems similar to UNISTRUT or other approved equivalent system. All vertical runs including cabling to switchboards, etc. shall be secured on approved type cable ladder system. For horizontal runs, cables shall be secured neatly on the cable trays or ladders at close intervals by means of moulded polythene cleats similar to BICC “Telecleat” or other approved equal whereas claw cleats shall be used for securing vertical cables. Fixing shall be made with rawl bolts or other patented fixing devices of manufacturer details to the Engineer approval. Details of cable routes, terminations and support system shall be forwarded to the Engineer for review prior to installation.

G. Armoured Cable Installation

1. Armoured cables shall be laid and secured on approved type cable ladder system similar to BICC VANTRUNK or other approved equivalent system. The cable ladder shall be supported on proprietary make support system similar to UNISTRUT or other approved system. For horizontal runs, the cables shall be secured neatly on the ladder at close intervals by means of moulded polythene cleats similar to BICC “Telecleat” or other approved equal whereas claw cleats shall be used for securing vertical cables. Fixing shall be made with rawlbolts or other patented fixing services of manufacturer detail approved by the Engineer. Details of cable routes, terminations and support system shall be forwarded to the Engineer for review prior to installation.
2. Compression type glands for the termination of armoured cables shall be included with the terminating boxes supplied under the Contract. Marshalling and other terminating boxes supplied under the Contract, however, are to include the cable terminating glands.
3. The manufacturer detail of compression glands is to be such that the cable is not twisted when the gland is tightened. They are to provide facilities for the efficient bonding and termination of the armour wires and are to project at least 20mm into the terminating box so that any condensation collected on the inner surfaces of the boxes cannot flow down between the cable cores. Where anti-condensation heaters are not fitted, drain holes are to be provided. It is to be possible to erect and dismantle any cable compression gland without the use of special tools. Termination shall have IP rating the same as that of the switch board or equipment where the cables are connected to.

2.04 Earth Continuity Conductor Installation

- A. Each circuit wire shall have its own protective conductor with adequately sized in accordance with BS7671 using stranded copper cable with green/yellow PVC insulation.

2.05 Cable Termination**A. Tee-off**

1. Tee-off as required for tapping of power supply from the main riser cables to individual circuits shall be suitable for such purposes. Installation method must be submitted for approval prior to commencement of works. Under all circumstances, the conductors to be tee-off shall be secured by means of proprietary made compression type mechanical connectors, enclosed in plastic protective shell and filled with acrylic resin. No strand of a stranded conductor shall be cut away in making the tee-off.
2. In the case of armoured cables, the earth continuity for the main cable and tee-off cable shall be maintained.

B. Cable Termination

1. Cable shall be terminated using suitably chosen cable glands as specified.
2. A PVC shroud as specified shall be fitted to cover the gland body.
3. In the case of armoured cables, all armour and all faces of armour clamps of connectors making contact with them shall be thoroughly cleaned before termination and the clamps shall be adequately tightened to ensure good electrical contact.
4. Cable conductor terminations shall be by means of heavy duty solderless cable lugs. The lugs shall be of high conductivity copper electro-tinned and applied to the conductor by means of a hydraulic crimping tool unless otherwise specified. Heat shrinkable tapes shall be used for insulating the termination whenever possible.

C. Armour Earthing

1. Metallic sheaths and/or armour of all cables in the same circuit shall be solidly bonded together at both ends of their runs. The bonding shall extend from the earth lug or earth lug attached to the cable glands to the main earth system.
2. The cross-sectional area of the bonding conductor shall be selected in accordance to BS7671.
3. The bonding conductor shall be as short and straight as possible.

2.06 Cable Identification

- A. Cables shall be provided with identification markers, at each end of the cable, at entry and exit points of buried ducts, and in such other positions as are necessary to identify and trace the route at any cable. Where cables are not enclosed in ducts and are of multiple runs, markers shall be provided at 15 meter intervals
- B. Cable identification shall be assembled from elliptical profiled plasticised PVC markers, carrier strip and nylon ties, the complete assembly shall be suitable for a maximum service temperature of 70°C.
- C. Every single core cable and every core of a multicore cable shall be provided with identification at its termination in the form of tapes, sleeves or discs of appropriate colours.

SECTION E 05
LOW VOLTAGE SWITCHBOARDS
1.0 GENERAL
1.01 WORK DESCRIPTION

- A. The switchboards, distribution boards and control panels shall be built in accordance with IEC 439 “Factory Built Assemblies for Low Voltage” or BS 5486 “Factory-built Assemblies of Switchgear and Control Gear for Voltage up to and including 1000 AC and 1200V DC.
- B. All factory built assemblies shall be capable of withstanding the electrical, mechanical and thermal stresses of the prospective fault level experience. The prospective fault levels of the various factory built assemblies shall be as indicated in the Drawings.
- C. All equipment used in the factory built assemblies shall have been type tested/partial type tested. Type set certificates shall be submitted for all major equipment at the time of technical submission.

Besides, a full type test report as specified under IEC 60439-1, the Low voltage switchboard shall also be tested for electromagnetic compatibility (EMC), internal arcing-fault test and seismic withstand test under the relevant standards.

- D. All factory built assemblies, as a complete unit shall have a rating equal to or greater than the integrated equipment rating as indicated in the Drawing.
- E. All factory built assemblies subject to rain or wet conditions or located outside electrical switch room shall be weatherproof constructed to IP 65, able to withstand high impact strength of 60 KN/m² (min), temperature resistant with consideration of Ambient temperature 50°C and average switch room temperature 35°C. Flame retardant and corrosion resistant.

1.02 STANDARDS

- A. The LV switchboards and distribution boards shall be constructed in accordance with the latest revision of the following standards:
1. BS 88 : Cartridge fuses for voltages up to and including 1000V AC and 1500V DC.
 2. BS 89 : Direct acting electrical indicating analogue electrical measuring instruments and their accessories.
 3. BS 142 : Electrical protection relays
 4. BS 159 : Busbars and busbar connections
 5. BS 1433 : Copper for electrical purposes. Rods and bars.
 6. BS EN 60898 : Circuit-breakers for over current protection for household and similar installations.
 7. BS 3938 : Current transformers
 8. BS EN 60947-2 : Low-voltage switchgear and controlgear. Circuit-breakers.
 9. BS 4794 : Control switches (switching devices, including contactor relays, for control and auxiliary circuits, for voltages up to and including 1000V AC and 1200V DC).

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| 10. | BS 5419 | : | Air-break switches, air-break disconnectors, air break switch disconnectors and fuse combination units for voltages up to and including 1000V AC and 1200V DC. |
| 11. | BS 5420 | : | Degrees of protection of enclosures of switchgear and controlgear for voltages up to and including 1000V AC and 1200V DC. |
| 12. | BS 5424 | : | Controlgear for voltages up to and including 1000V AC and 1200V DC Contactors. |
| 13. | BS 5486 | : | Low-voltage switchgear and controlgear assemblies. Specification for type tested and partially type tested assemblies.(General requirements) |
| 14. | BS 5685 | : | Electricity meters – Specification for Class 0.5, 1 and 2 single phase and polyphase, single-rate and multi-rate watt-hour meters. |
| 15. | BS 5992 | : | Electrical relays. |
| 16. | BS 6004 | : | PVC insulated cables, non-armoured, for electric power, lighting and internal wiring. |
| 17. | BS 6231 | | PVC insulated cables for switchgear and controlgear wiring. |
| 18. | BS7430 | | Code of practice for Earthing |
| 19. | IEC 60439-1 | : | Low-voltage switchgear and controlgear assemblies Type-tested and partially type-tested assemblies |
| 20. | AS 3439-1 | : | Low-voltage switchgear and controlgear assemblies. Type-tested and partially type-tested assemblies |
| 21. | IEC 68-3-3 | : | Environment testing: Guidance Seismic test methods for equipments. |

B. BS/IEC or other National standards not mentioned above but are applicable to this installation shall also apply.

1.03 SUBMISSION

- A. A component list and catalogues.
- B. Detailed shop drawings of all factory built assemblies shall be submitted for approval before construction commences.
- C. Such drawings shall show the proposed method of construction of the cubicles, method of supporting equipment and busbars, full details of busbar layout, method of support, electrical control wiring diagrams, equipment weight, colours, surface treatment and mounting type etc.
- D. The drawings shall also incorporate a full list of proposed materials. The construction shall not commence until the drawings are approved for construction.
- E. Factory and site testing procedures and report formats shall also be included.

2.0 PRODUCTS

2.01 GENERAL

- A. The factory built assemblies shall be of the totally enclosed, modular cubicle type, which are extensible and suitable for floor mounting as indicated in the drawings. The assemblies shall be manufactured in a facility that is ISO 9000 certified.
- B. The factory built assemblies shall be compartmented and utilize sheet steel plates of thickness as detailed below. The panels shall be vermin proof and constructed to a minimum degree of protection of IP ratings to BS 5420. The IP ratings indicated below shall be applicable unless otherwise indicated in the drawing.
- C. Main and Sub-Switchboards
 - 1. 2mm thick sheet steel
 - 2. Form 2b, Type 2 for Main Board and for Emergency Board, unless otherwise specified to BS 5486 with separation of busbars from the functional units and separation of all functional units from one another
 - 3. Minimum IP 44 and IP 2X after opening of doors & panels (of external covers) unless otherwise specified.
 - 4. IP65 for location subject to rain wet conditions or located outside electrical switch room.
 - 5. Switchboard frame shall be of modular detail and extensible.
 - 6. The interior of each cubicle shall be dust inert and vermin resistant.
- D. Switchboard frames shall be fabrication of 2.0mm thick electro-galvanized steel. All joints shall be neatly formed and finished flush with the adjacent surfaces by grinding and/or machining. No joints shall be located on a corner and all bare edges shall be lipped.
- E. Structural members and bracing, where necessary, shall be welded or bolted to the frame.

2.02 DOORS AND PANELS

- A. Full access shall be provided to service and maintain all equipment inside each cubicle by means of a suitable hinged door that shall open a minimum of 120 degrees. All hinged doors shall have an earth braid connected to the cubicle.
- B. Doors and panels shall be constructed of 2 mm electro-galvanized sheet steel, pressed or rolled so that edges are given a neat round finish and shall reinforced with a suitable frame welded to the inside folded edge of the door. An approved stiffener shall be welded to the inside of each door and/or panel.
- C. Doors shall hang on substantially concealed non-corrosive hinges and shall be fitted with good quality door handles to Engineer's approval which shall be lockable and operable by the same key. The door handles shall be fitted with toggles to operate rods to latch with suitable slots in both the top and bottom of the switchboards. Latching rods shall be guided by brackets. The latching rods and associated brackets shall be cadmium plated.
- D. All front, side and top panels shall be constructed in a manner similar to that specified for doors above. They shall be fitted to the frame from the outside with captive, hand tightened screw. Panels longer than 1.2 meters shall be provided with 3 point locking system

2.03 BASEPLATE AND INSULATING PANELS

- A. The switchboards shall be mounted on 50mm X 50mm C-channel. Wherever insulating panels are required to mount special equipment, they shall be of high quality black bakelite, polished on the front.
- B. All edges must be cut straight and square and shall be chamfered on the front edge with a 3mm chamfer.

2.04 FINISHING OF METAL WORK

- A. Panel work of the switchboards shall be finished with electrostatic epoxy powder coating of minimum 50 microns all treat with 180⁰C 12 minute oven backing. All metal work shall be rust inhibited and sprayed with two coats of primer. The painting shall be of best quality oven-bake epoxy powder coated, of Grey colour.
- B. After erection on site and after all inspection and tests have been carried out, the Contractor shall thoroughly clean all painted parts, touch-up with application of an additional coat of anti-corrosive structural priming paint to any part of the originally painted surfaces that have been scratched or otherwise marked and at least one additional touch-up finishing coat of Grey colour.

2.05 BUSBARS AND CURRENT CARRYING PARTS

- A. The manufacturing of the busbar system shall comply to the latest edition of BS 159. All busbars and current carrying parts shall be manufactured to carry a current density of not more than 1.55 A/mm² and shall be capable of carrying normal current continuously without the temperature rise of any part exceeding 30⁰C. Their location shall be such as to ensure adequate spacing between conductors and they shall be securely fastened and braced to withstand all stress set up during transportation, erection and normal operation, and under short circuit conditions. The busbars shall not be damaged in any way under a fault of short circuit experience with minimum 46 MVA for 3 seconds. Where two or more conductors are used to form a phase, it shall be separated with an air gap sufficient to allow for the ventilation of the individual conductors all round. Busbar supports shall be made of slotted first grade "Bakelite" or glass fiber reinforced polymer able to withstand minimum operating temperature of 110⁰C.
- B. All connections in current carrying parts shall be made by means of bolts with lock nuts. The use of tapped holes and studs or any other alternative method of connection in current carrying parts shall not be employed without the express approval of the Engineer prior to manufacture.
- C. Busbars shall be provided with approved shrinkable tube of adhesive stickers of appropriate phase colour to indicate phases.
- D. All connections, tapping and clamping shall be made in an approved manner to ensure minimum contact resistance. All connections in the busbars shall be firmly bolted and clamped with even tension. Before assembly, all busbar joint surfaces shall be filed or finished to remove burrs, dents and oxides and silvered to maintain good continuity at all joints.
- E. All intermediate conducting material shall be used when there is a possibility of electrolytic action when contacts of the copper busbars with dissimilar metals are made.
- F. An earth bar minimum size comply with BS7671 and BS7430 with minimum 50mm x 10mm to each vertical section of the cubicle units and shall run the full length at the bottom of each switchboard. All metal parts of the switchboards and associated

equipment shall be bonded and connected to this earth bar. Minimum 2 connections to main earthing system shall be provided. The protective circuit shall have a rated conditional short circuit current of 39kA at 240V and a rated peak and short-circuit withstand current of 81.9kA and 39kA for 1 sec respectively.

- G. The neutral busbar shall be the same size of that of the phase bars and shall be provided with an adequate number of terminals including cable lugs, bolts, etc. to suit the installation.
- H. For circuits not less than 200A, busbar drops to moulded case circuit breakers or other apparatus shall be made of circular or rectangular busbar covered with Nylex tubing of appropriate colour and terminated in adequately sized concentric lug, of lug type, cone grip cable sockets or approved equal. Cables may be used for circuits less than 200A to type test configuration.
- I. All visible rectangular busbars shall be bare tinned type size $1.55A/mm^2$ based on current density. Rated current of assembly shall be based on tinned busbar and must be certified by type testing.
- J. All screws, bolts, washers used for the busbars shall be cadmium plated. All contact parts of the busbars and connections shall be sanded and coated with a thin coat of chemical inert petroleum jelly. All bolts shall be tightened with an even tension. Approved spring washers shall be used at all joints complete with cadmium plated high tensile steel bolts.
- K. All busbars and switchgear terminals to which outgoing or incoming cables are terminated shall be manufactured for a maximum temperature of $30^{\circ}C$ above ambient. Where there are two incomers to the Low voltage switchboard, the bus-coupler and the busbar works shall type tested to certify the integrity of the system.

2.06 INSULATION

- A. The clearances and insulation shall be such as to withstand the standard 3 kV dielectric tests on the switchboard.
- B. All insulation used shall be of the best quality and sufficiently strong to withstand all stresses which may be imposed on it in the ordinary erection and operation of the switchboards.
- C. Where insulators are cemented or jointed to metal parts, such jointing shall be of such a nature that no dangerous stresses are set up in the insulators by the unequal expansion or contraction of the insulation and the metal through the range of temperatures stated.

2.07 CABLE OR BUSDUCT ENTRIES

- A. Provision shall be made within the factory built assemblies for the proper support and bracing of outgoing and incoming cables or busducts.
- B. Weatherproof cable glands and all necessary non-ferrous gland plates, etc. shall be provided for all cables entering or leaving the switchboards. Cable terminating end boxes shall be mounted from top of the switchgear in the cubicles. Cable supports shall be provided for the termination boxes.
- C. Busduct entries to the switchboard shall be liaised with busduct vendor for the exact position and phasing.

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- D. Detail of cable or busduct in and out of the switchboard shall take into the IP rating requirement as specified for the switchboard.

2.08 PHASING

- A. Phase rotation shall be strictly maintained throughout the project, and shall comply with the requirements of BS 258. Phase distinguishing colours shall be RED, YELLOW and BLUE.

2.09 LABELS

- A. All factory built assemblies and equipment shall be clearly labeled in accordance with Local Authority's regulations and to indicate its functions by means of engraved 'Traffolite' labels. Plastic labels are not acceptable. Emergency Main Switch Board shall be "red-on-white" others shall be "black-on-white". Engraved lettering not less than 20mm high or as otherwise required and approved.
- B. Labels shall be attached by means of chrome finished countersunk screws and nuts.
- C. Prior to engraving the labels, a label schedule shall be submitted for approval. Cost for two sets of labels shall be included in the Contract to cater for any amendment to the label as directed by the Engineer.

2.10 SPECIFICATION FOR SPARES

- A. The switchboards shall incorporate a rack for mounting spares, moulded case circuit breakers and a minimum of 10 percent standby/spare capacities shall be provided for future installation of circuit breakers.
- B. End covers and pre-drilled holes at main busbars shall be manufactured for future extension of the switchboards at both ends.
- C. Spare shall be provided according to those as specified in the DB schedule/Single line diagram.

2.11 BASE SUPPORTS

- A. The base support shall be fabricated from 50mm x 50mm C-channel base sufficiently stiffened to adequately support the switchboard. The base shall be hot dip galvanized after fabrication. The base may be made as part of the switchboard.

2.12 VENTILATION

- A. All switchboards shall be properly natural ventilated. Force ventilation to achieve the required rating of the assembly is prohibited.
- B. Vents shall be provided with the consideration of IP rating as specified.
- C. Detailed calculation shall be submitted to verify the total heat from the switchgear and switchboard and the amount of vents and ventilation fans size.

2.13 INDICATING INSTRUMENTS

- A. Indicating instruments shall comply with BS 89. Meters for external panel mounting shall be of the flush pattern type with square escutcheon plate's finished matt black and polycarbonate cases.

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- B. The main low voltage switchboards shall be provided with High performance and high accuracy power meter/ Energy Analyzer with LCD display that capable of indicating real-time readings, demand reading, energy readings, set up and resets menus shall be installed for the main switchboards. Power meter shall be provided for the circuits above 100A or as specified on the drawings.
 - C. The reading shall include but not limit to current (per phase, neutral and earth), voltage (L-L, L-N), real power, reactive power, apparent power, power factor, frequency, energy, power quality readings such as voltage and current THD, demand, date/time stamping, on-board memory for alarms/relay functions such as under/over conditions, phase unbalance conditions, data log, event log, etc.
 - D. The meter power shall accept inputs from standard 5A current transformers and has full-scale input of 10A. The voltage inputs shall be directly connected to 3 phase circuits of 600V and below without the need for Potential or current transformer. All reading shall be scaled to their actual values without the need for a multiplier.
 - E. The power meter set up and resets shall be password protected and easily done via the meter display or via network software.
 - F. In addition, unless otherwise specified, following analogue indicating instrument shall be installed for sub-bard and distribution boards above 100A incoming or as specified on the drawings.
 - G. Ammeter and voltmeters shall be of moving iron coil spring controlled type with 96mm square dials, accuracy Class 1.5 with external zero adjustment screw that is accessible from the front.
 - H. Ammeters shall be selected such that full load current indications are not less than the two thirds of linear scale of the meter and have a suppressed upper scale.
 - I. Ammeters shall be capable of taking overloads of 2 times continuously and voltmeter 1.2 times continuously.
 - J. Ammeters at the main incoming feeders shall in addition to the moving iron mechanism be provided with thermal bimetal indicators with draw pointers to record maximum demands. The mechanism shall not respond to short current peaks and shall be manually resettable.
 - K. Frequency indicators shall be of the vibrating reed type. The meter shall be capable of proper operation for voltage variation of $\pm 10\%$ rated voltage.
 - L. Power factor meters shall be of the electro-dynamics crossed coil mechanism suitable for balance load, three phase four-wire system. The accuracy class shall be 1.5 and range 0.5 lag to 0.5 lead.
 - M. Monitoring Kilowatt-Hour Meters and current transformers where specified shall be provided. The kilowatt-hour meter shall have a digital display reading up to 100 million Kilowatt-Hours and to the nearest 100 KW-Hr. The overall accuracy shall be better than $\pm 2.0\%$.
 - N. The KWh meters shall be of flush mounting, rear connection type, current transformer operated and suitable for three phase balanced and unbalanced loads. The meter shall be complete with the three metering elements and shall have a cyclometer register with six rollers.

- O. Instrument dials shall be white with black markings, and scales shall be of such material that ageing, peeling or discoloration will not take place under tropical conditions.
- P. All instruments, when mounted on the switchboard, wired and ready for service, shall be in good order and condition in every way. The measuring elements shall be completely free from any discernible stickiness either at zero or upscale, and they shall be capable of attaining the performance guaranteed by the manufacturers of the respective instruments.
- Q. All terminals shall be completely insulated and potential circuits shall be suitable fused.

2.14 SELECTOR SWITCHES

- A. The switches shall be of the panel mounting type with totally enclosed contacts and stud connection. Ammeter selector switches shall have make before break contacts to ensure that the current transformers are never open circuited.
- B. The ammeter selector switch shall be suitable for measuring the current in each phase independently.
- C. The voltmeter selector switcher shall be 7-way type. Voltmeter selector switches shall have break before make contacts.

2.15 CURRENT TRANSFORMERS

- A. Current transformers necessary for the operation of instruments and meters shall comply with BS 3938 and be of the 'straight through' epoxy-resin type. Measuring current transformer shall be of accuracy class 1 and for metering of accuracy Class 0.2(for energy metering).
- B. They shall be adequately rated in V.A. to carry the summation of all V.A. burdens of connected loads, and shall be capable of carrying current of the corresponding circuit breakers and fuses. The output secondary current shall be 5 amperes.
- C. They shall be capable of operation, without damage, with open circuited secondary and full load current flowing in the primary.
- D. Current transformers shall be adequately supported and installed as to permit easy access and to be readily replaceable, if necessary, without dismantling of adjacent equipment.
- E. All current transformers shall be provided with an identifying label giving type, ratio, class, output and serial number.
- F. Current transformers provided for protective gear purposes shall have overcurrent and accuracy limit factors not less than those corresponding to the short circuit level of the system. The output of each current transformer shall be not less than that specified and the capacity of the current transformers provided shall be adequate for operation of the associated protective devices and instruments. Where double ratio secondary windings are specified, a label shall be provided at the secondary terminals of the current transformer indicating clearly the connection required for either ratio. These connections and the ratio in use shall be shown on the appropriate schematic and connection diagrams. Protection current transformer shall be of a accuracy Class 5P 10 and the burden in no case shall be less than 15VA.
- G. Magnetization curves shall be submitted at the time of shop drawing submission.

2.16 CONTACTORS

- A. Contactors shall be fully tropicalised and robust construction and shall comply with relevant parts of BS 5424 and be rated for the following duties.
- B. Contactors for voltages up to and including 1000 volts A.C. and 1200 volts D.C. (BS 5424 Part 1).
 - 1. Rated duty - Uninterrupted
 - 2. Mechanical duty - Class I
 - 3. Making and Breaking - AC4 Category
- C. Contactors shall be selected to suit the load such that a minimum electrical life of one million operations is ensured. The mechanical life shall be at least 5 million operations.
- D. Contactors shall have at least 15 times making capacity and 10 times breaking capacity for contactors less than 100 amps and 10 times and 8 times respectively for contactors above 100 amps. The selection of contactors shall be coordinated with the prospective fault levels suitable at that point of installation.
- E. Contactors shall generally be suitable for rail mounting and be of modular detail. The coil shall be suitable for +10% and -15% of nominal main voltage. Provision shall be made on the contactors for affixing of termination and contactor identification labels.
- F. Contactors shall be provided in sheet steel enclosure of a tropical finish and vermin proof. Adequate ventilation shall be accordance with BS 5424, category IP 42 for indoor service and IP 65 for outdoor service.
- G. The contactor shall be located within the enclosure so that upon making or opening of the contactor under normal or fault conditions, damage will not be caused to other equipment and wiring within the enclosure.
- H. An isolating switch shall be provided for each contactor circuit except that if there is more than one contactor and they are grouped together, one incoming supply isolating switch shall be provided to isolate all contactor circuits. A mechanical interlocking device between the isolating switch and panel cover shall be provided to prevent access to live parts within the panel when the isolating switch is in the "ON" position.
- I. Contactors equipped with both local and remote control shall have local/remote changeover switches capable of being locked by padlock in the either position.
- J. Contractor shall be provided with spare auxiliary (2 No. + 2 NC) in addition to other required auxiliary contacts specified in the Contract.

3.0 RELAYS

3.01 CONTROL RELAYS

- A. All control and indication relays shall be of the heavy-duty pattern fully tropicalised type.
- B. Relays shall be grouped conveniently in dust proof cases with removable covers given access for adjustment, cleaning, etc., without dismantling the relay.

3.02 PROTECTION RELAYS

- A. Protection relays shall be approved types complying with BS 142 or equal and shall have approved characteristics and be flush mounted in dust proof cases. Relay cases shall generally be finished in black enamel.

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- B. Relays shall be of construction detail arranged so that adjustments, testing and replacements can be effected with the minimum of time and labour. Relays of the hand reset type shall be capable of being reset without opening the case.
 - C. Relay contacts shall make firmly without bounce and the whole of the relay mechanisms shall be as far as possible unaffected by vibration or external magnetic fields.
 - D. Relays, where appropriate shall be provided with flag indicators of approved type, phase coloured where applicable. Flag indicators shall be of the hand-reset pattern and shall be capable of being reset without opening the case. Where two or more phase elements are included in one case separate indicator shall be provided for each element.
 - E. Relays with provision for manual operation from outside the case, other than resetting will not be accepted, and time delay relays shall not be of the dashpot type.
 - F. Relays shall be provided with clearly inscribed labels describing their application and rating in addition to the general-purpose labels.
 - G. Approved means shall be provided on the relay panels for the testing of protective relays and associated circuits. Withdrawable type cases and plug-in type test facilities being preferred.
 - H. Full discrimination relay curves indicate relay setting shall be co-ordinate by the Contractor and submit for approval. The submission shall cover both O/C & E/F protection up to final circuit and shall be endorsed by the Contractor's Installation Engineer.

3.03 OVERCURRENT PROTECTION

- A. Overcurrent protection shall be of the current transformers operated direct acting type. Where instantaneous trip is specified, the relay shall incorporate an electronic timer with adjustable time delay setting.
- B. Where IDMT characteristic is required the time/current characteristic shall comply with BS 142. IDMT type relay shall consist of an electromagnet with shading rings on the pole pieces driving an induction disc. Current setting shall be of a plug and bridging socket arrangement and time lag setting shall be by setting screw located above the time scale.
- C. Overload phase indicator shall be provided to show the phase overload condition.
- D. The range of current setting adjustment for phase faults shall be 50% to 200% of rated full load with tapping at 25% intervals and the time setting adjustment shall be 0 to 3 seconds at 10 times the normal operating current. The current/time characteristics of the relays shall be in accordance with the British Standard Curve and shall be provided during the technical submission.
- E. Both electromechanical and electronic type protective relays may be considered. Submission of full technical detail and approval shall be obtained prior to installation.

3.04 EARTH LEAKAGE PROTECTION

- A. The earth leakage relays shall be of the instantaneous type with adjustable current settings from 5% to 40% in 5% steps.

- B. The operating coils and contacts shall be adequately rated to carry the necessary load. Operating indicator and reset facilities shall be provided.
- C. The relays shall house in dust proof sheet metal casings, provided with viewing glass.
- D. Both electromechanical and electronic type protective relays may be considered. Submission of full technical detail and approval shall be obtained prior to installation

4.0 CONTROL CIRCUIT WIRING AND AUXILLARY

4.01 CONTROL CIRCUIT WIRING

- A. All wiring shall be arranged in a regular manner with bends set at 90 degree and securely held in position with suitable clips and where convenient shall be installed in the uprights and/or back-stays insulating bushes being used where necessary.
- B. Control wiring of the switchboard shall be carried out in PVC insulated switchboard cable of size not less than 1.5mm^2 and those for current measurement shall be minimum 2.5mm^2 . All meter wiring shall be of similar colours to those of the respective busbars, etc., to which connections are made. The cable termination shall be made with cable lugs.
- C. No wires/cables shall be tee-off or jointed between terminal points.
- D. Wiring shall be carried out in such a manner as to make circuits and connections easily traceable. Cable marking ferrules or similar shall be used at each termination. Terminals shall be designated in an approved manner.
- E. All terminals shall be fitted with brass washers and securely fixed with lock nuts.
- F. Displacement Insulation push-in type termination for cable up to 2.5mm^2 , tunnel type terminals shall be provided for cables up to and below 6mm^2 . Cables larger than 6mm^2 shall be terminated with compression cable lugs or proprietary makes of termination approved by the Engineer.

4.02 ANTI-CONDENSATION HEATERS

- A. Anti-condensation heaters shall be fitted in each cubicle together with an ON/OFF isolating switch and adjustable thermostat suitable for electrical operation at 230 volts A.C. 50 Hz single phase of sufficient capacity to raise the internal ambient temperature by 5°C . The electrical apparatus so protected shall be detailed so that the maximum permitted rise in temperature is not exceeded if the heaters are energized while the switchboard is in operation.
- B. As a general rule, the heaters shall be placed at the bottom of the cubicle.

4.03 TERMINAL BOARDS

- A. All terminal boards shall be mounted in accessible positions and, when in enclosed cubicles shall be inclined downwards towards the door. Spacing of adjacent terminal boards shall not be less than 100 mm and the bottom of each board shall not be less than 200 mm above the incoming cable gland plate. Separate studs shall be provided on each terminal strip for the cores of incoming and outgoing cables including all spare cores.
- B. Brass bolts and studs shall be of not less than 6 mm diameter size but stainless steel and bronze down to 4.5 mm diameter may be used provided that the current carrying capacity

is adequate. All studs shall be provided with nuts, washers and lock nuts or lock washers. Where pinch type terminations shall be provided. They shall have adequate current carrying capacity and shall be provided with locking devices. Insulated barriers shall be fitted between adjacent terminals.

- C. 400/230 volt and higher voltage circuit terminals shall be segregated from other terminals and shall be fitted with non-flammable transparent plastic covers to prevent contact with any live parts. They shall have warning labels with red lettering, mounted thereof in a conspicuous position.
- D. All connections shall be made at the front of the terminal boards and no live metal shall be exposed at the back.

4.04 FUSES AND DISCONNECTING LINKS

- A. All fuse link and disconnecting link assemblies associated with electrical installation, instrument, protection and control circuits shall be of approved type and grouped as far as possible according to their functions. They shall be clearly labeled, both on the panels and the associated wiring diagrams.
- B. Fuse link and disconnecting link assemblies associated with tripping circuits shall preferably be mounted on the outside of controlling compartment. All others shall be mounted internally.
- C. Carriers and base for flush links shall be black. Disconnecting link carriers and bases shall be white.
- D. All fuse links shall be High Rupturing Capacity (HRC) cartridge type and all fuse switches and distribution boards and the like shall be suitable for the accommodation of these fuses.
- E. Each cartridge shall incorporate a fuse element of appropriate current rating and fusing factor in order that adequate protection and discrimination is provided to the circuit.
- F. The high rupturing capacity (HRC) cartridge fuses of rating shown shall conform to BS 88 Part 2 Class Q1 with minimum breaking capacity of 80 KA. When fuses are used for motor protection they shall have Class R rating. Fuse bases and carriers shall be made of high-grade phenolic moulding.

4.05 PUSH BUTTON

- A. All the push buttons shall be made of non-hygroscopic material, non-swelling and fitted to avoid any possibility of sticking. Unless otherwise specified, they shall be of the non-retaining type. All push buttons shall have minimum IP54 ingress protection rating.
- B. The contacts of all push buttons shall be of adequate strength and have a positive wiping action when in operation.

4.06 INDICATING LAMPS AND FITTINGS

- A. Indicating lamps fitted to the fascias of switch and instrument cubicles or panels shall be adequately ventilated.
- B. Lamps shall be easily removed and replaced from the front of the panel by manual means not requiring the use of extractors.

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- C. The bezel of metal holding the lamp glass shall be easily removable from the body of the fitting so as to permit access to the lamp and lamp glass.
 - D. The lamps shall be clear and shall fit into an accepted standard form of lamp holder. The rated lamp voltage shall be 4% in excess of the auxiliary supply voltage AC230V and DC 48V.
 - E. The lamp glasses/lens shall be in the standard colours, red, yellow, blue and amber. The colour shall be in the glass/lens and not an applied coating and the different colored glasses/lens shall be interchangeable.
 - F. Neon indicating lamps shall not be used with coloured lens.
 - G. Unless otherwise indicated or agreed with the Engineer, all lamp colours shall conform to the following practice:
 - 1. Red - red phase;
 - 2. Yellow - yellow phase;
 - 3. Blue - blue phase;
 - 4. White - supply available.
 - 5. Red - fault

4.07 RADIO INTERFERENCE SUPPRESSION

- A. All Plant and apparatus, including such items as contactors, starters, relays and the like where the normal operation is such that interruption of low frequency or direct current occur, shall be fitted with means of suppressing all interference frequencies caused.
- B. The standard of interference suppression shall be in accordance with the current edition of BS 800 incorporating all amendments but extended to include the frequency ranges 300 to 360 MHz and 1.000 to 3,400 MHz.
- C. Details of the equipment and methods to be used in quantitative assessment of the level of radio interference shall be as specified in BS 727.
- D. For guidance in the installation of electrical equipment to meet the foregoing standards, reference shall be made to BS Code of Practice CP:1006 "General Aspects of Radio Interference Suppression: which deals with interference caused by electrical apparatus and installations.

4.08 SURGE PROTECTION DEVICES

- A. Surge Protection devices shall be provided whichever cable route from external or to external of the building.

5.0 EXECUTION

5.01 TESTING AND COMMISSIONING

- A. All switchboards shall be tested and certified by the installation Engineer that it is safe before supply is energized, and that all the equipment comply with the requirements of the Specification.
- B. Generally such tests in the factory and repeated at site are as follows:
 - 1. Insulation resistance tests;
 - 2. Earth continuity tests;

3. Dielectric test – 3 kV DC for 1 minute;
 4. Check of clearance and creepage distances;
 5. Tests to prove correct operation of controls, interlocks, tripping and closing circuits, indications, etc.;
 6. Phasing tests;
 7. Operation of all protective gear circuits by primary injection and system fault tests to check sensitivity and stability;
 8. Test of accuracy of all measuring instruments;
 9. Test operation of alarm devices;
 10. Interfacing test with BMS
 11. Checking of all internal cabling and function operation;
 12. Above tests are minimum requirement and shall include all other tests required by the Engineer to verify compliance with the Specification.
- C. Triplicate sets of all principal test records and test certificates are to be supplied for all the tests carried out in accordance with the Specification to the Engineer for approval before dispatch from the switchboard factory.
- D. All costs, materials, equipment, labour, etc. necessary for the execution of the testing shall be included in this portion of work.
- E. The Contractor shall include the cost for the requirement for witness at Manufacturer for Factory Test, the Engineer and Employer representative – 2 persons 3 days (excluding transport time) for tests.

5.02 TRANSPORTATION

- A. Switchboards are not allow to be delivered to site until the electrical room or switchroom is in a clean and acceptable condition with lockable doors.
- B. Switchboards transported to site shall be fully covered with weatherproof covers and transportation eye bolts shall be provided for handling at site.
- C. Switchboards which are poorly packed and result in signs of corrosion will be rejected.
- D. All necessary measures to cover and protect the switchboards at site shall be provided. Such measures shall include a complete PVC blanket over the whole switchboard or distribution board.

5.03 REJECTION OF SWITCHBOARD

- A. If any of the above tests fail to comply with the requirements of this Specification in any respect whatsoever at any stage of manufacture, test, erection or on completion at site, the Engineer may reject the item or defective component thereof, whichever is considered necessary, and after adjustment or modification as directed by the Engineer, the Contractor shall submit that item for further inspection and/or test. In the event of the defective item being of such nature that the requirements of this Specification cannot be fulfilled by adjustment or modification, such item is to be replaced by the Contractor at his own expense, to the entire satisfaction of the Engineer. Delivery of switchboard on site without significant cable connection (Say 80%) shall not entitle progress payment certified for material delivery on site.

5.04 EARTHING

- A. Suitable earthing terminals or studs shall be provided on the frame for the connection of 25 mm x 3 mm copper strip to the main earthing bar in the switchroom.

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- B. A main earthing bar of HDHC copper with cross-sectional area in compliance with BS7671 and BS7430 50 mm x 6 mm shall be provided in the switchroom and to which all earthing connections shall be made. This earthing bar shall run along the wall adjacent to the full length of the main switchboard. Two connections to main earthing system shall be provided.

5.05 PROVISION OF ELECTRICAL SERVICES AND EQUIPMENT TO MEET LOCAL AUTHORITIES' REQUIREMENT

- A. All other requirements by Local Authority that are imposed in the course of execution of the work, particularly those listed below shall be provided.
1. Danger signs;
 2. Rubber floor mat of 6m thickness and 1 meter width provided for the full length of the switchboard;
 3. A dry chemical type fire extinguisher of 9 kg capacity with approved label;
 4. Framed single line diagram with minimum A1 size endorsed by Contractor's Qualified personnel;
 5. 'First-Aid' Demonstration sign;
 6. Sand for cable trenches after completion of all cable installation work, if applicable.

SECTION E 06**LUMINAIRES AND ACCESSORIES****1.0 General****1.01 Work Description**

- A. The luminaires schedule indicates the detail requirement of the luminaires selection. The exact luminaires of the installation subject to Engineer approval on the sample. The Contractor shall be responsible to ensure the selected luminaires suit the location of installation. No time and cost adjustment for the Contractor to provide the approved selected luminaires.
- B. The Contractor shall co-ordinate the fixing detail of the luminaires, any accessories, brackets, waterproof termination box etc, required to complete the installation shall be included in the Contract
- C. Certain types of electrical equipment or systems involving sudden changes, or low frequency or of direct electric current such as fluorescent lamps, contactors, etc. shall be fitted with radio and television interference suppression components suitable to meet the levels specified in BS 800 "Limits of Radio Interference characteristics of household electrical appliances".

1.02 Standards

- A. The manufacturing of the luminaires shall also conform to the requirements of all relevant local codes, as applicable, together with the additional requirements referred to in this Specification and Drawings, whichever is the more stringent and acceptable to the Engineer.
- B. In the adoption of standards and requirements, the Contractor shall take the following precedence:
 - 1. Engineer's decision;
 - 2. Local codes of practice;
 - 3. Drawings;
 - 4. Specification;
 - 5. International standards and requirements.

1.03 Submission

- A. All technical submissions shall be approved by the Engineer prior to the respective stages of construction.
- B. As a minimum requirement, the submission shall include the following:
 - 1. Luminaires colour cut sheet submission with manufacturer's data, lamp date, IP rating, location of installation, quantity.
 - 2. Sample submission;

3. Lit-up sample submission as required by Engineer.
4. Lit-up sample for all lamp with indication of location of installation and manufacturer recommended lamp life span.
5. Illumination computer print out for area as required by Engineer.
6. Shop Drawings of the fixing details showing the coordinated installation details.
7. test reports for all emergency use luminaires.
8. Builder's works requirement.

2.0 Product

2.01 Internal Wiring within Luminaires

- A. Cables interconnecting components shall be heat resisting cables and shall be neatly bundled by nylon self-locking cable ties and shall be properly routed and secured away from heat generating accessories like control gear, etc.
- B. Cables used for internal wiring of the luminaires shall be of appropriate type and size. The insulation of the cables shall be able to withstand throughout the life of the luminaires the maximum temperature of not less than 105⁰ C.
- C. Where wiring passes through the edge of any metal section of the fitting, it shall be protected by an approved grommet. All connections of wires to terminals shall be of approved types. All wirings shall be concealed from view with the luminaires installed.
- D. All cable terminations within the luminaires shall be suitably shrouded. At every luminaires, an earthing terminal shall be provided for connection to the circuit protective conductor.

2.02 Fluorescent Tubes and PL Lamps

- A. Fluorescent tubes shall be energy saving type and shall comply with BS1853 and shall be as indicated on the luminaires Schedule. Fluorescent tubes shall be triphosphorus coated type and having an efficacy of not less than 96 lumen per lamp watt for standard fluorescent tubes.
- B. PL lamps shall be of single-ended miniature fluorescent lamps each consisting of two narrow glass tubes welded together with a bi-pin cap and housing for starter and capacitor at one end.
- C. Lampholders for PL lamps shall be of type G23 suitable to receive the bi-pin cap of the PL lamps. Power factor correction capacitors shall be provided to correct the power factor to better than 0.9 lagging.

2.03 Fluorescent Fittings

- A. Except where specified or shown as being aluminium, metalware for florescent fittings, reflectors, channels, etc., shall be constructed from mild steel or zinc anneal sheet not less than 1 mm thickness. All corners and joints exposed to normal view shall be welded, ground smooth and filled where necessary before painting.

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- B. Fittings shall have closed ends unless otherwise specified or detailed. Where a diffuser is specified the diffuser shall be for the full length and width of the fitting with a surrounding flange where applicable. Diffusers shall be arranged so that they are hinged frame supported, or where specified to the contrary, hinged or removable and held by chains for maintenance.
 - C. After fabrication, metal surfaces shall be thoroughly cleaned back to the parent metal and all dust, moisture grease or oil shall be removed.
 - D. All scale and corrosion products shall be removed after which the finished article shall be cleaned with trichloroethylene.
 - E. The metalware shall be spray painted with high grade polyester powder coat on both sides and stoved. Total thickness of paint build up shall be not less than 50 micron. Finished colour shall be to approval on all surfaces.
 - F. All fittings shall be adequately ventilated to maintain the tube wall operating temperature below 65°C (50°C ambient).
 - G. All plastic diffuser shall be of non-deteriorating, colour stable material and of acrylic material.
 - H. Recessed lighting fittings shall be supported from the RC ceiling slabs using appropriate fixing accessories such as steel rod, spring clips, ceiling brackets, suspension hooks, profile brackets, etc. to ensure proper Installation of the fittings on different types of ceiling panels. Where light fittings are installed directly below large ductworks etc., the Contractor shall install suitable brackets, channels, etc. to facilitate suspension/support of the light fittings from the ceiling slabs. An adjustable resilient spring-clip shall be provided to enable the suspension length to be adjusted to fine tolerances. Suspension sets shall be adjustable proprietary make type manufactured to carry the weight of the lighting fittings and shall be of adequate lengths for installation on the false ceiling panels concerned. Suspension rods shall be of least 5mm diameter and shall fixed at positions recommended by the lighting fitting manufacturers.
 - I. At least four (4) suspension rods shall be provided for each fitting. Lighting fittings shall be supported in a manner that will ensure that the weight of each fitting is equally distributed to all supporting rods with the fitting remaining in level position. Suspension sets where exposed to sight shall be of adjustable rod type of minimum diameter 20mm with all necessary accessories.
 - J. Louvered mirror reflectors of the fluorescent lighting fittings where called for shall be manufactured for low brightness performance with double parabolic faceted, pre-anodized high purity aluminium of 88% reflectance, with minimum of glare to comply with Category 2 of CIBSE Lighting Guide LG3:1989 latest edition. The louver reflectors shall have a light output ratio of at least 70%.
 - K. All diffusers shall be hinged at one side of the fitting for maintenance purposes and snap fit back into position.
 - L. All light fittings used as emergency lights including exit signs shall be constructed and installed In accordance with the current edition of BS5266 Code of Practice for the

Design, Installation and Maintenance of Emergency Evacuation Lighting and Power Supply Systems in Buildings. Exit signs shall be complied with Civil Defence requirements.

- M. Identification symbol in accordance with BS5266 shall be displayed on or adjacent to each emergency lighting fitting. The symbol shall not be fixed to the diffuser of an emergency lighting fitting or to removable ceiling tiles.

2.04 Control Gears for Fluorescent Luminaires

- A. All electrical control gears shall be totally built into the fitting assembly. Separate ballast, starter and power factor correction capacitor shall be provided for individual lamp. All control gears shall be rated for $230V \pm 10\%$ AC voltage supply.
- B. Ballasts shall be low loss type with a maximum of 6 watts loss at rated voltage and wattage comply with BS 2818 where required.
- C. Power factor correction capacitors complying to BS 4017 shall be provided to correct the power factor for each lamp to not less than 0.9 lagging two (2) hours after continuous operation of the lamp. All capacitors shall be fitted with suitable internal discharge resistor. Power factor capacitors shall be of a type manufactured for continuous operation in an ambient temperature of 50°C . Capacitors shall be fitted with leads in lieu of terminals so that the component is not exposed when fitting is opened.
- D. Starters shall be complete with bases and shall of the glow type with bi-pin to comply with BS 3772. A radio interference suppression capacitor shall be fitted internally within the starter.
- E. Control gear shall be suitably selected to suit the requirements of switching and/or dimming control as specified on the Specification Drawings.
- F. Electronic ballasts shall be of high frequency fixed output type, low loss of less than 5 watts, suitable for T5 slim fluorescent tubes. All electronic ballasts shall comply with IEC928, IEC929 and BSEN55015 where required.

2.05 Tungsten Lamps

- A. Tungsten filament lamps shall be of the general lighting services pattern or otherwise of the coiled coil type in applicable sizes. Clear lamps shall be utilized in all fittings with the exception of open base glassware in which case lamps shall be of the silica coated type. Lamps shall be manufactured to BS 161 for general service type, and BS 1522 for projector lamps class B.1 and B.2.
- B. All lamps shall be provided with Edison Screw (ES). holders.
- C. Lamps of coiled coil filament type shall have a nominal life of 1000 burning hours.

2.06 High Intensity Discharge (HID) Lamps and Control Gears

- A. High Intensity Discharge (HID) lamps where called for shall be manufactured to BS 3677 as appropriate.

- B. Appropriate inductive ballasts for limiting the current shall be used in conjunction with the HID lamps and that the control gears installed shall be suitable for the lamps used. The control gears (ballasts, igniters, capacitor or etc.) for each lamp shall be suitable for enclosing in a weatherproof compartment where used for external areas or integrated with the luminaires. Ballasts shall be the low loss type manufactured to BS EN 60922 and rated for operation at $230V \pm 10\%$ 50 Hz single phase AC supply. Ballasts shall be vacuum impregnated or polyester filled to ensure good heat dissipation and maximum protection from moisture and corrosion. The ballasts shall be of low noise type and shall be mounted tightly on a rigid part of the lighting fitting. No one component of the lighting fitting shall be loose and badly fastened which might become resonant. Power factor of each lamp circuit shall be maintained at better than 0.9 lagging.

2.07 Lamp Life Span

- A. All luminaires manufacturing shall be considered the heat dissipation requirement, waterproof, insect proof, and vibration requirement at the location of installation. Any luminaires installation installed on site should have minimum lamp operation life not less than 80% of the average lamp life according to the lamp manufacturer recommended. Any installation have shorter lamp life should consider as the luminaires are not manufacturing to suit the location of installation. The Contractor should be responsible to replace all the luminaires to acceptable selection at Contractor own cost. Any related cost to other parties to carry out the replacement should also be responsible by the Contractor.

SECTION E 07
WIRING DEVICES

1.0 **GENERAL**

1.01 **WORK DESCRIPTION**

- A. The drawings for the lighting and power points indicate approximate positions of all lighting fittings, switches, power outlet points, isolating switch points and the like. The actual positions of all fittings, switches, the wiring details and cable routes shall be co-ordinated with M&E Services on site and submitted for the approval of the Engineer. All time and cost required adjusting the layout or adjusting the completed installation to Engineer satisfaction and to suit site co-ordination is included in the Contract.
- B. During the exact positioning of lighting and power points, due consideration shall be given to the operational requirements of the installation, the selection of the most accessible routes for wiring and the convenience of switching.
- C. No additional cost will be entertained should the final positions be relocated within the same room or not more than five (5) metres away from the original locations due to any requirement.
- D. For the purpose of this Specification and related Drawings, each lighting and small power point circuits shall in general be coded with a prefix to indicate the corresponding distribution board number; details on the circuit way and phase shall be submitted for the approval of Engineer.
- E. Certain types of electrical equipment or systems involving sudden changes, or low frequency or of direct electric current such as fluorescent lamps, contactors, etc. shall be fitted with radio and television interference suppression components suitable to meet the levels specified in BS 800 "Limits of Radio Interference".
- F. This section included the specification of the following :
1. 13A Switched Socket Outlet
 2. Fused Connection Unit
 3. Lighting Switches
 4. 15A Switched Socket Outlets
 5. Lighting Point Installation
 6. Weather Proof Isolator
 7. Isolating Switches
 8. Telephone/Data Outlets
 9. Contactors
 10. Lighting Dimmers Switch
 11. Time Switch
 12. Water Heater Switches
 13. Power Supply for Lighting at Wet Condition

1.02 **STANDARDS**

- A. The complete wiring installation shall be engineered according to manufacturer data and constructed in accordance with the latest revision of the following standards and the appropriate BS/IEC:
1. BS7671 : Requirements for Electrical Installation

2. BS 1363 : 13A Switched Socket Outlet
3. BS 3676 : Lighting Switches
4. BS 546: 15A Switched Socket Outlets
5. BS 800: TV & Radio Frequency Interference
6. BS 1362 : 13A Cartridge Fuse-Link for Fused Connection Units
7. BS 3052 : Shaver Outlets
8. BS 3676 : Isolating Switches
9. BS 4662 : Conduit Boxes
10. BS 5424 : Contactors

B. In the adoption of standards and requirements, the Contractor shall take the following precedence:

1. Engineer's decision;
2. Local codes of practice;
3. Drawings;
4. Specification;
5. International standards and requirements.

1.03 SUBMISSION

A. All technical submissions shall be approved by the Engineer prior to the respective stages of construction.

B. As a minimum requirement, the submission shall include the following:

1. Equipment catalogues submission with manufacturer's data;
2. Sample submission include all wiring accessories;
3. Shop Drawings of the lighting and power positions, circuit numbers, cable routings, switching arrangement, mounting height, etc. The positions and mounting heights shall be coordinated with other services. Fixing details of all wiring accessories shall also be included.
4. Drawings showing the installation details.
5. Labeling system
6. Builder's works requirement.

2.0 PRODUCT

2.01 LIGHTING POINT INSTALLATION

A. The various types of light fittings to be supplied and installed are described in the drawings and the Schedule of Lighting Fittings on Drawing

B. Surface mounted light fitting shall terminate at a BS 4662 junction box having entries appropriate to the run of conduit and shall be complete with porcelain connector suitable for the size and number of connections to be made at the point and the wiring required to connect the specified fitting. Wiring to the light fittings within the false ceiling spaces shall be by means of heat resistant (butyl or silicon rubber insulated to BS 6500) cables i.e. between the junction box and the lamp holder/terminal blocks, in flexible conduits.

C. At every light fitting an approved type earthing terminal shall be provided for connection of the circuit protective conductor of the final circuit.

D. Ferrous metalwork shall be of minimum thickness of 1mm. treated against corrosion by galvanizing after welding or be lead primer or other approved process. Metalwork shall be

painted with one priming coat, one under-coat and two top coats finished stove-enamelled matt white, unless otherwise specified.

- E. Cables used for internal wiring of the lighting fittings shall be of appropriate type and size and number. Conductor shall be of size not less than $1.5 \text{ mm}^2/1\text{C}$ or the equivalent. The insulation of the cables shall be able to withstand throughout the life of the fitting the maximum temperature to which it will be subject in normal use without deterioration which could affect the safety of the fitting.
- F. Cables within the lighting fittings shall be neatly bundled by nylon self locking cable ties; wiring shall be properly routed and secured away from control gear etc. wherever possible.
- G. All cable terminations within the light fittings shall be suitably shrouded to the approval of the Engineer.
- H. All lighting fittings shall be self-supporting complete with the appropriate fixing accessories such as clips, supporting brackets, suspension sets, nuts, washers, screws etc. for the proper installation of the fittings on different types of ceiling panels. Suspension sets shall be of adjustable type suitable to carry the weight of the lighting fittings and unless otherwise stated or indicated on Drawings, the suspension sets shall be generally 900 mm in length; exact lengths required shall suit site situations.
- I. All lamps complete with control gear necessary in operational condition shall be provided together with the lighting fittings as specified.

2.02 SWITCHES

- A. Lighting switches, unless otherwise specified, shall be single pole, quick make and slow-break, silent switch action type with solid silver alloy contacts and totally enclosed switch action for flush or surface mounting as required.
- B. Lighting switches shall be suitable for indoor or outdoor service according to location, housed in standardized purpose manufactured galvanized steel boxes completed with conduit knockouts made up into single or multi-gang units employing a grid switch system of fully interchangeable components at standardized fixing centers of matching switches of different types and ratings but of identical dimensions, push buttons, neon indicator lamps, blanking units, grids, steel boxes and plates all capable of integration into standard composite assemblies in any combination as required.
- C. Grids shall be adjustable for variation in depth of plaster and for squaring errors and of the same type for surface or flush mounting.
- D. Switches for public areas shall be of special designs/finishes, in accordance with the specific "Designer Range Series" of the products, selected and approved by the Engineer. Switches of other areas shall be of high-impact resistant polycarbonate. Colour finishes shall generally be in white, as selected and approved by the Engineer. Switches in mechanical plantrooms and electrical sub-stations and switchrooms shall be of the metal clad type approved by the Engineer, mounted in flush or surface conduit boxes as specified elsewhere.
- E. Switches located on brick or concrete walls shall be mounted in horizontal arrangement in plaster depth steel boxes or in galvanized steel boxes using box suspension straps and cover plates. Countersunk screws shall be provided for fixing to the conduit boxes.
- F. Switches for external use shall be of weatherproof construction with IP65 rating, unless otherwise specified.

- G. Samples of all switches, conduit boxes and plaster depth boxes shall be submitted to the Engineer for approval prior to installation.
- H. Samples shall be rated for 10 Amps (minimum light switch rating 10A), 15 Amps or 20 Amps as determined by circuit load which for inductive lighting circuit shall be assessed at twice the steady state connected load current, one way or two ways as indicated on the drawings and fixed generally at a height of 1200 mm from floor level and where located in rooms the switch shall, where possible be located on the inside of the room on the handle side of the door as close to the door as is practicable.
- I. An earthing terminal, connected to the earth continuity terminal shall be provided and connected to the circuit protective conductor at every lighting switch positions.
- J. Single pole switches shall be connected to break the phase wire of the supply; the neutral wire shall not be routed through switch boxes.
- K. Switches which are mounted in the same location shall be of multi-gang type, of the maximum number of gangs available.
- L. All switches used shall be of an approved or prescribed item as required by local Authorities.
- M. Circuit from different phase and circuit from emergency power should have separate switch plate.

2.03 SWITCHED SOCKET OUTLETS

- A. Switched socket outlets shall be to BS1363 single pole 13 Amp 3 rectangular pin switch shuttered outlets, one or two gang for indoor service except otherwise specified and either surface or flush mounting according to location.
- B. Switches shall be of the quick-make slow break type with silent, totally enclosed switch action and solid silver alloy contacts. Switched socket outlets for indoor use shall be housed in suitable galvanized steel boxes to BS 4662 with conduit knockouts. Types and finishes of socket plates shall match those for the lighting switches.
- C. Generally switched socket outlets shall be positioned 300 mm above floor level except in plant rooms, kitchen, etc. where they shall be positioned 1400 mm above floor level or 150 mm above counters or benches whichever is suitable.
- D. Switch socket outlet in all mechanical plant rooms, electrical switch rooms shall be of the metal clad type, with recessed or protected switch dolly, mounted in flush or surface conduit boxes as specified elsewhere.
- E. All switched socket outlets used shall be of an approved or prescribed item as required by the local Authorities.

2.04 FUSED CONNECTION UNIT

- A. All fused connection units shall be double pole switched, rated at 13 Amp unless otherwise specified, with fuse-links to BS 1362.
- B. Units shall be of moulded ivory plastic, flush mounted, suitable for housing into galvanized steel boxes to BS 4662 with conduit knockouts.

- C. Fused connection units shall be of the same manufacture as 13 Amp socket outlets and of matching appearance.
- D. Fused connection units provide supply to gas ignition of home appliance shall not be located in gas pipe compartment.

2.05 ISOLATION SWITCH

- A. Isolating switches shall be of the current ratings and number of poles (generally double pole for single phase and 4-pole three phases) as indicated on the Drawings.
- B. Isolating switches shall be of the totally enclosed pattern, metal-clad or polycarbonate with positive quick-make and quick-break action.
- C. Switches shall be capable of passing and also interrupting their full rated current safety and without damage.
- D. Ferrous materials shall be galvanised, switch handles shall be interlocked to prevent opening the cover with the switch "ON".

2.06 15 AMP SWITCHED SOCKET OUTLETS

- A. 15 Amp switched socket outlets shall be 3 pin round type to BS 546 shuttered, of a finished similar to 13 Amp switched socket outlets and flush mounted in galvanised steel conduit boxes to BS 4662 requirements.

2.07 WEATHERPROOF ISOLATOR

- A. Weatherproof enclosure shall be of the high impact, water resistant to IP65. The isolator provided shall complete with lockable device. Isolators shall be double-pole, 4-pole as specified.

2.08 LIGHTING DIMMERS SWITCH

- A. Lighting dimmer switch shall be the solid state, variable load, thyristor controlled type suitable for controlling fluorescent and or incandescent lighting circuits operating at 230V \pm 10% 50Hz single phase AC supply.
- B. Dimmer switch shall be manufactured to eliminate TV and radio frequency interference in compliance with BS 800.
- C. The ratings of the dimmer units shall be suitable for lighting circuit specified on Drawing.

2.09 TIME SWITCHES

- A. Time switches shall be self-contained units suitable for mains operation. All units shall have a self-starting synchronous motor with a single-pole fuse in the motor circuit, a 3-way terminal block and a thirty-six (36) hours spring reserve complete with an automatic solar dial.
- B. When fitted, the solar dial shall be capable of switching ON at sunset and OFF at sunrise throughout the year by control of a secondary calendar dial with month and day settings, and the automatic switching time shall be adjustable.
- C. Time switches shall be encased in a dust-tight metal casing have a hinged front cover with a clear perspex window. The casing shall be effectively earthed.

- D. A manual bypass switch shall be incorporated with the time switch to facilitate maintenance of the latter.

2.10 CONTACTORS

- A. Contactors for lighting control, whether locally, remotely or through timer, shall comply with BS 5424: Part 1, utilization category AC-2, Class 3 intermittent duty, and shall have a current rating of not less than that of the outgoing switchgear to which they are connected, and in any case not less than 20A.

2.11 TELEPHONE/DATA OUTLETS

- A. Telephone/Data outlets where called for shall be single or twin of the flush mounted type suitable to receive the plug-in telephone/data cable lead to the approval of the Local Authority. The finishes of the telephone/data outlet plates at various areas shall be as specified for lighting switches.

2.12 WATER HEATER SWITCHES

- A. Water heater switches shall be flush mounted conforming to BS 3676 having double pole AC switch rated at 20 amps fitted with pilot lamp and marked "water heater". The cover plates shall be of the same finish as those specified for the other switches. Associated connector units shall be provided next to the water heater units.

2.14 POWER SUPPLY FOR LIGHTING AT WET CONDITION

- A. Residual Current Circuit Breakers shall be provided individually for each circuits serving lighting subject to wet condition.

SECTION E 8
FIRE ALARM SYSTEM
1.0 General
1.01 Work Description

- A. The work under this section consists of supplying, installing, testing and commissioning of all material and services of complete Fire Alarm System as stated herein, as shown on Tender drawings and as given in the Bill of Quantities.
- B. The Contractor will discuss the electrical layout with the Engineer and coordinate at site with other services for exact route, location and position of electrical lines and equipments.
- C. The Fire Alarm System with accessories shall also comply with the basic electrical requirements for Electrical Works Section 01 and with other relevant provisions of the Tender Documents.

1.02 Submission

- A. All technical submissions shall be approved by the Engineer prior to the respective stages of construction.
- B. As a minimum requirement, the submission shall include the following:
 - 1. Equipment submission with manufacturer's data.
 - 2. Sample submission including all types of detectors, sounder, manual call points etc.
 - 3. Drawings for field equipment showing the co-ordinate routing of cable routings and details coverage calculations of detectors.
 - 4. Builder's works requirements.

1.03 Applicable Standards / Codes

- A. The following standards & codes shall be applicable for the materials covered within the scope of this section:
 - 1. NFPA 72 : National Fire Alarm Code
 - 2. NFPA 101 : Life Safety Code

The system shall have ability to perform satisfactory under conditions of electrical surges and transients, and shall comply fully with the requirement of the following standards as required by EN54:

- 1. IEC 801 – 2 : Electrostatic discharges
- 2. IEC 801 – 3 : Radiated Electro magnetic interference
- 3. IEC 801 – 4 : Voltage transients – Fast transient bursts.

Each and all items of the Fire Alarm System shall be listed as a product of a single fire alarm system manufacturer under the appropriate category by Underwriters Laboratories (UL) & shall bear the UL label. Equivalent DIN or British standard shall also be acceptable.

1.04 General

- The Standalone Fire Alarm System shall be used for detection, warning and control function in case of fire. The sensors shall have the following general properties:

- Sensors shall be provided with ionization sensing chamber with nominal sensitivity of 1.07%/ft.
 - The unit shall be capable of self restoring.
 - Sensors shall have the fully screened sensing chamber to resist entry of small insects thereby reducing the probability of unwanted alarms.
 - Shall have a full function test button. The test button should check all alarm functions by simulating the chamber to simulate a smoke/heat condition, causing a unit to alarm.
 - Sensors shall be ceiling mount and shall contain mounting hardware.
- The Contractor shall provide wall chart for operation and maintenance of Fire Alarm System. The wall chart shall contain following minimum information in both English and Urdu languages.
- Complete layout of Fire Detection & Alarm system showing locations of all fire zones, and bells zones in two different colours.
 - Standby battery specification, including ampere-hour capacity Voltage per Cell, number of Cells, and the battery type.
 - Operating and maintenance instruction in BLACK colour.
 - Emergency instructions in RED colour.
 - Name, address & telephone number of the servicing contractor.

The characters of written instructions shall be minimum 6 mm high.

2.0 Material

2.01 Standalone Smoke Sensors with Sounder

The Smoke Sensors shall be of battery operated single station with alarm and will work on disturbance of current following between two electricity charges plates, caused by a radioactive material placed between the plates. A sensor shall have a visual LED power-on indicator to confirm unit is receiving power or is in alarm.

- Operating Voltage : 9VDC
- Monitoring : Open and short circuit fault, sensor removal and device type.
- Area Coverage : 90 m²
- Temperature Range : 4°C to 38°C
- Audio alarm : 85dB at 10ft
- Alarm Reset : Automatic when smoke clears
- Sensor : Dual chamber Ionization

2.02 Standalone Heat Sensors with Sounder

The heat sensors shall use an electronic sensor to measure thermal conditions caused by a fire. Heat sensor shall have following minimum technical specifications.

- Operating Voltage : 16–26VDC

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- Monitoring : Open and short circuit fault, sensor removal and device type.
 - Area Coverage : 80 m²
 - Temperature Range : 54°C to 70°C
 - Audio alarm : 85dB

3.0 Installation

3.01 Fire Alarm System Equipment

The installation of Fire Alarm system equipment shall be in strict accordance with the manufacturer's instructions/recommendations and these specifications.

The testing of Fire Alarm equipment shall be in compliance with the relevant standards and regulations. During testing of equipment, emphasis shall be laid on the following:

- Operational Safety
- Regular functioning of the devices
- Protection against false alarms

Detectors shall be subjected to the basic tests and sensitivity tests. The automatic detectors shall be tested in various ways to check real and false alarm behaviors.

4.0 Training

A training session shall be presented by a fully qualified, trained representative of the equipment manufacturer/supplier who is thoroughly knowledgeable of the specific installation. The training shall be given to personnel responsible for operation and maintenance of the system.

The training session shall include but not limited to the following:

- 4.1 Detailed explanation of wall charts as mentioned in Article 1.04 of this section.
- 4.2 Function of each control switch
- 4.3 Periodic operational testing of devices.
- 4.4 Maintenance of fire log book supplied by manufacturer.
- 4.5 Actions to be taken upon receiving following signals:
 - 4.5.1 False alarm indication
 - 4.5.2 Trouble on any initiating or indicating zone
 - 4.5.3 Common alarm or common trouble indication
 - 4.5.4 Low battery voltage indication
- 4.6 Field modifiable programming.

5.0 Testing

Provide the service of a competent, factory -trained engineer or technician authorized by the manufacturer of the fire alarm equipment to technically supervise and participate during all of the adjustments and commissioning of the system.

1. Before energizing the cables and wires, check for correct connections and test for short circuits, earth faults, continuity, and insulation.
2. Verify activation of all flow switches.
3. Open initiating device circuits and verify that the fault signal actuates.
4. Open signaling line circuits and verify that the fault signal actuates.
5. Open and short indicating appliance circuits and verify that fault signal actuates.
6. Earth initiating device circuits and verify response of fault signals.
7. Earth signaling line circuits and verify response of fault signals.
8. Earth indicating appliance circuits and verify response of fault signals.
9. Check presence and audibility of tone at all alarm notification devices.
10. Check installation, supervision, and operation of all intelligent smoke sensors during a walk test.

SECTION E 9**EARTHING SYSTEM****1.0 GENERAL****1.01 WORK DESCRIPTION**

- A. This section specifies the engineering, supply, installation, testing, commissioning and setting to work of the complete earthing network for individual earthing systems, circuit protective conductors and bonding conductors. A complete earthing network comprising cables, copper tapes, electrodes and earth bonding of all relevant necessary non-current carrying metal shall be supplied, erected and connected as required.
- B. The system shall be a common earthing system as described in the Specification and as shown on the Drawings. Individual earthing systems shall be provided as follows prior to any according to drawing. Earth main LV/Generator Electrical Earthing shall have 2 connection to the earthing system:
1. LV Electrical Earthing;
 2. Generator Earthing;
 3. ELV Earthing;
 4. Data Earthing;
 5. Local Authority'st Earthing;
- C. Sufficient numbers of electrodes interconnect by copper tape or conductors to form earthing mat so that the overall earth resistance shall be less than 1 ohm for each individual earthing mat.
- D. The numbers of earth electrodes of the earthing mat are indicated on the drawings as minimum. The Contractor shall test the resistivity of soil at site. Exact number of earth electrodes shall be determined by the Contractor to achieve the earth resistance value subject to Engineer approval. The complete earthing installation include earth rod / plate, earth mat detail to achieve the earth resistance value shall be included in the Contract.
- E. The Contractor shall inform the Engineer or his representative before driving stainless steel copper claded earthing rods into the ground so that he may supervise the operation. Driving shall be carried out only in the presence of the Engineer or the representative as per defined procedure in drawings, BOQ & Specifications and all rods shall be submitted for the examination before use.

1.02 STANDARDS

- A. Complete earthing system shall be engineering and constructed in accordance with the latest revision of the following standards and the appropriate BS/IEC:
1. BS7671 : Requirements for Electrical Installation
 2. BS7430 : Code of practice for Earthing
 3. BS EN 62305 : Protection against Lightning
 4. IEC 61024-1-2 :Protection of Structures against Lightning
- B. The detail of the Earthing System shall also conform to the requirements of all relevant local codes, as applicable, together with the additional requirements referred to in this Specification and Drawings, whichever is the more stringent and acceptable to the Engineer.

-
- C. In the adoption of standards and requirements, the Contractor shall take the following precedence:
1. Engineer's decision;
 2. Local codes of practice;
 3. Drawings;
 4. Specification
 5. International standards and requirements.

1.03 SUBMISSION

- A. All technical submissions shall be approved by the Engineer prior to the respective stages of construction.
- B. As minimum requirement, the submission shall include the following:
1. Equipment Schedule, including all manufacturer's data;
 2. Shop Drawings and Sample Submission;
 3. Builder's work requirements;
 4. Testing procedures and report format for testing of the earth electrodes and/or earth strips;
 5. Soil resisting test report with calculation report for the details of the earthing system detail including quantity and layout of earth electrodes and/or earth strips to achieve the required earth resistance. The report shall be endorsed by the Contractor's Installation Engineer who supervise and endorse the installation upon completion;
 6. Proposed details of earthing system including quantity and layout of the earth electrodes and/or earth strips according to the calculation result.

2.0 PRODUCT

2.01 GENERAL

- A. Common earth mats of resistivity of less than one (1) ohm, shall be constructed below the lowest floor structure prior to any ground work construction. The copper earth mats shall comprise the complete earth electrodes, earth strips/grids, earth inspection chambers, earth leads, main earth terminals, earth test link boxes at ground level, etc. Under this circumstance, each individual earthing system shall have earth leads connecting its main earth terminal directly to an earth electrode underground as specified.
- B. In the case where drilling is required to take the earth rods or copper tapes below ground level, a specified earth resistance enhancement compound shall be added into the bored holes and a mixture at 60% bentonite and 40% of gypsum to 125% of water mixed to give thick slurry. It shall be grouted into the holes prior to inserting of rods or tapes, and be allowed to solidify. The hiring of machine drilling equipment and the grouting as described above shall be provided by the Contractor.
- C. The earthing system shall be formed from copper conductors.
- D. All copper clips, holdfasts, clamps, earth rod clamps, etc. shall be supplied by the same manufacturer of the copper tapes and rods.
- E. All earthing products/accessories shall be of Local Authority's approved type.
- F. The mating surface of all tapes/conductors at joints etc shall be cleaned before clamping and all joints shall be riveted, joint with proper connector or exothermic welded. All

connectors to electrical apparatus shall be made by a bolted connection in a visible and accessible position

- G. Copper conductor shall be secured with appropriate size copper saddles at intervals not exceeding 600 mm and the conductor shall be supplied in long unbroken lengths to avoid unnecessary jointing.

2.02 EARTH ELECTRODE

- A. Earth electrode rods shall be minimum 20 mm diameter extensible copper type with internal screw and socket joints, driving head and connection clamp.
- B. Stainless steel copper claded rods shall have tensile strength of approximately 600 N/m².
- C. Couplings for each section of the rod shall be of same material of the rod, threaded to fit the rod sections. Driving studs shall be used when driving the electrode into the ground. Earth values shall be measured and recorded before coupling and driving in the next section. Additional earth rods shall be driven in if necessary to attain the required effective earth values.
- D. Clamping of the earth leads to the earth rod shall be made by earth clamp. The clamps shall be capable of providing a high pressure contact between the earth rod and the earth leads to achieve a low contact resistance.
- E. When two or more electrodes are driven to form a group, the heads of the electrodes in the group shall be bonded to each other by means of a 25 mm x 3mm copper tape/70sqmm copper conductor, laid at a depth of at least 600 mm in soil.
- F. All earth electrode penetrations through basement water proofing membranes shall be provided with manufacturer's recommended water seal insert sleeve approved by Engineer. The installation of the water seal insert sleeve shall be under the supervision and endorsed by the manufacturer's representative to ensure the installation comply with the manufacturer installation detail.

2.03 EARTH INSPECTION CHAMBER

- A. Earth electrode shall be fitted with a heavy-duty precast concrete inspection chamber/pit complete with heavy-duty cover as specified on drawings.
- B. For earth electrodes located outside or on the apron of the building, earth inspection chambers shall extend to a depth of not less than 300 mm below finished ground level and kept free of soil. For earth electrodes located inside building, earth electrodes shall be buried not less than 100 mm below the floor slab structure. Each earth electrode shall be clearly marked 'SAFETY ELECTRICAL EARTH CONNECTION – DO NOT REMOVE.
- C. The chamber and cover shall be heavy duty detail to consider the traffic load at the location of installation. The cover shall be recessed cover to receive the Architectural floor finish at the location of installation.

2.04 EARTH LEAD

- A. Earth leads, also commonly known as earth conductors, shall be used for the final connection between the earth electrodes and the main earth terminals.

- B. Unless otherwise specified, earth leads shall be of 16sqmm copper conductor.

2.05 EARTH CONNECTING POINT (ECP)

- A. Earth connecting point shall be of copper 300x50x6mm in size as specified.
- B. ECP shall be CAD welded or joint with proper connector to earth electrodes underground below the floor slab structure, and shall be buried not less than 300 mm below the floor slab structure.
- C. In order to minimise the mutual inductance between conductors, earth conductors shall be positioned at a distance not less than 6m apart unless otherwise specified.

2.06 MAIN EARTH TERMINAL

- A. Main earth terminals shall be provided for the termination of each earthing system. 50mm x 6 mm tinned HDHC copper earth bars not less than 300mm in length shall be installed in the respective plant rooms / switch rooms at a height of 300 mm above finished floor level. The insulators shall be the approved type. Interconnection between plant rooms / switch rooms and connection to earth electrodes shall be minimum 2 direct connection and as per the Drawings and/or as required to complete the installation.
- B. Suitable earthing terminals shall be provided in all the equipment housings, switchgear enclosures, relayed and instrument casings and all other electrical metalwork for bonding to earth.
- C. The earth connections for all sections of the installation shall be electrically continuous throughout back to the corresponding main earth terminals.

2.07 CONNECTIONS

- A. Joints in the earth bars, copper tapes/ conductor and earth mats shall be exothermatically or butt weld or brazed such that the resistance of the section containing the joint shall not exceed that of an equivalent length at unjointed conductor. Any joint so made may be required to be tested to prove compliance with the requirement.
- B. The contact faces of all protect conductors shall be cleaned and tinned before connections are made.
- C. No drilling of the earth bar shall be permitted except in terminations.

3.0 EARTH BONDING

3.01 CIRCUIT PROTECTIVE CONDUCTOR

- A. Circuit protective conductor (cpc) is a system of conductors joining together all exposed conductive parts and connecting them to the main earth terminal.
- B. The purpose of circuit protective conductor is to provide a path for earth fault circuit so that the protective device will operate to remove dangerous potential differences during a fault condition.
- C. The circuit protective conductors shall take the form of separate cable with a sheath in green/yellow colour or copper conductor of minimum size 70sqmm.

- D. All exposed non-current carrying metal parts of light fittings, switchgears, motors, enclosures, etc. shall be effectively earthed by circuit protective conductors for earth continuity protection.
- E. For equipment where an earth terminal is provided, the earth continuity wire shall be firmly clamped. Where no earth terminal is provided, the exposed metal part shall be cleaned of paint and surface rust before welding the earth continuity lead.
- F. The minimum size of the principal protective conductors shall be as indicated below, the sizing of principal protective conductors shall be in accordance with to the current edition of BS7671 and BS7430.

Description		Min. Conductor Size
1.	Earthing conductor between the earth electrode and the MV switch room main earth terminal.	2 x 70sq mm (c/w 2 x 70 sq mm in ring to other main earth terminals)
2.	Earthing conductor between the earth electrode and the main earth terminal at LV switchroom.	2 x 70 sq mm (c/w 2 x 70 sq mm in ring to other main earth terminals)
3.	Circuit protective conductor between MV main earth terminal and the transformer neutral point.	2 x 95 sq mm (c/w 2 x 95 sq mm in ring to other main earth terminals)
4.	Circuit protective conductor between MV main earth terminal and MV switchboard	2 x 70 sq mm in ring
5.	Circuit protective conductor between LV main earth terminal and the LV switchboard.	2 x 70 sq mm in ring
6.	Circuit protective conductor between the earth electrode and the Generator room main earth terminal.	2 x 95 sq mm (c/w 2 x 95 sq mm in ring to other main earth terminals)
7.	Circuit protective conductor between Control Room / Local Authority's MDF room main earth terminals and their corresponding earth electrodes.	2 x 70 sq mm (c/w 2 x 70 sq mm in ring to other main earth terminals)

- G. The external earth terminal on the outside of the end panel of any switchboard shall be connected to the main earth bar provided in two independent points.
- H. Circuit protective conductors shall be provided in electrical and mechanical rooms and along the routes for the bonding of all exposed conductive parts and extraneous conductive parts. A suitably sized earth terminal shall be provided at each zone of the building for this purpose.
- I. All exposed conductive parts shall be effectively connected in an approved manner to the principal protective conductors. The circuit protective conductors shall be single core copper cables or high conductivity annealed copper tapes specified. Unless otherwise specified, the minimum cross-sectional area of the circuit protective conductors shall be selected in accordance with BS7671:

<u>Cross Sectional Area (mm²) of Phase Conductors (S)</u>	<u>Cross Sectional Area of Earthing or Protective Conductor (mm²)</u>
S ≤ 16	S
16 < S ≤ 35	16
S > 35	S/2

An Earthing or Protective conductor size beyond 185mm² is considered not necessary.

3.02 MAIN EQUIPOTENTIAL BONDING CONDUCTOR

- A. This is referred to the conductor for the equipotential earth bondings of the metalwork of other services such as gas and water to the earthing system. This bonding of service pipes shall be made as close as possible to their point of entry to a building.
- B. All extraneous conductive parts of the following services shall be connected to the main earth terminal by means of main equipotential bonding conductors:
 1. Main water pipes;
 2. Main gas pipes;
 3. Other service pipes and ducting;
 4. Risers of central heating and air conditioning system;
 5. Exposed metallic parts of the building structure and as required by the Engineer;
 6. Breeching inlets;
 7. Fuel inlets.
- C. The metalwork of public gas and water service shall not be used as a sole protective earth electrode.
- D. Main equipotential bonding conductors shall have cross-sectional areas not less than half of the cross sectional area of the earth conductor of the installation, subject to a minimum of 6 mm² for copper cables. A conductor size beyond 25mm² for copper cables, theoretically, is considered not necessary.
- E. Location of all incoming pipes and ducting shown on the Drawings are indicative only and are to be coordinated on site.

3.03 SUPPLEMENTARY EQUIPOTENTIAL BONDING CONDUCTOR

- A. This is referred to the conductor for the equipotential earth bonding of the metalwork which is not associated with the electrical installation but which may provide a conducting path giving rise to shock.
- B. All extraneous conductive parts of the following shall be connected to the earthing system by means of supplementary equipotential bonding conductors:
 1. Metal tanks;
 2. All metallic cat-walks, platforms, handrails, staircases, ladders within 2m reach of pipes, tanks, cable trays cable ladders, trunking etc which have equipotential bonding.
 3. Any metallic cat-walks, platforms, handrails, staircases, ladders etc with attached electrical cabling or fittings;
 4. Metallic door frames/doors controlled by electromechanical locking mechanism with an operating voltage or supply voltage exceeding 50V.

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5. Metallic support to electrically operated equipment without direct electrical contact with the equipment;
 6. Electrically operated roller shutters;
 7. Metallic wall cladding containing, or immediately adjacent to, electrical socket outlet or other sources of electricity;
 8. Raised floor system;
 9. Electrical facilities in toilets and shower rooms;
 10. Exposed metallic parts of building structure, including roof trusses. (if roof trusses connect to lightning conductor earth, no further equipotential bonding is required).
- C. The requirement does not apply in the following instances:
1. Steel reinforced concrete poles in which the steel reinforcement is not accessible;
 2. Exposed conductor parts which owing to their reduced dimensions or their disposition cannot be gripped or cannot be contacted by a major surface of the human body, provided that connection of these parts to the protective conductor cannot readily be made or cannot be reliably maintained. This item applies to small isolated metal parts such as bolts, rivets, nameplates and cable clips. A major surface of the human body is considered to be 50mm x 50mm.
 3. Fixing screws for non-metallic accessories provided that there is no appreciable risk of the screws coming into contact with live parts.
 4. Short lengths of metal conduit for mechanical protection of cables having a non-metallic sheath.
- D. Local supplementary bonding conductors shall be provided between simultaneously accessible (i.e. within 2m) exposed conductive parts of equipment, between exposed conductive parts and simultaneously accessible extraneous conductive parts, and between simultaneously accessible extraneous conductive parts. The bonding conductors shall be single core copper cables with oversheath in green/yellow colour.
- E. Supplementary bonding, conductors shall be sized in accordance with BS7671 which can be summarized as follows:
1. For conductors connecting two exposed conductive parts, the conductor sizes shall not be less than the smaller protective conductor connected to the exposed conductive parts, subject to a minimum of 4 mm^2 if the cables are not mechanically protected;
 2. For conductors connecting exposed conductive parts to extraneous conductive parts, the conductor sizes shall not be less than half that of the protective conductor connected to the exposed conductor parts, subject to a minimum of 4 mm^2 if the cables are not mechanically protected;
 3. For conductors connecting two extraneous conductive parts, the conductor sizes shall not be less than 4 mm^2 , or even 2.5 mm^2 if mechanically protected, for copper conductors.
- F. All equipment equipotential bondings in area other than plant rooms and within false ceiling shall be concealed. Any remedial work required due to bad connection, open circuit, etc. shall be borne by the Contractor;
- G. All earth conductors and earth terminals shall be manufactured to carry the maximum short circuit current at the point of the installation.

SECTION E 10**LIGHTNING PROTECTION SYSTEM****1.0 GENERAL****1.01 WORK DESCRIPTION**

- A. The work to be done under this section comprises the engineering, supply and installation necessary for the complete installation of the Lightning Protection System.
- B. The Lightning Protection System shall be installed generally in accordance with BS EN 62305 and IEC 61024-1-2 and additional requirements of this specification. The system shall be of the Faraday-cage type and shall consist of air terminations, down conductors, joints and bonds, testing joints, earth terminations and earth electrodes. The general arrangement shall be as indicated on the Drawings.
- C. The lightning protection system shall comprise:-
 - 1. Air Terminations;
 - 2. Down Conductors;
 - 3. Joints and Bonds;
 - 4. Test Links
 - 5. Earth Terminations.
- D. Lightning protection system employing minimum 50sqmm stranded bare copper conductor as part of the down conductors shall be adopted as per Drawing specified. All requirements in the specification included down conductors shall be applied unless otherwise specified.

1.02 STANDARDS

- A. Complete installation shall be engineering and constructed in accordance with the latest revision of the following standards and the appropriate BS/IEC :
 - 1. BS EN 62305 - Protection against Lightning
 - 2. AS1768 - Lightning Protection
 - 3. BS7671 - Requirements for Electrical Installation
 - 4. IEC 61024-1-2 - Protection of Structures against Lightning
- B. The detail of the lightning protection system shall also conform to the requirements of all relevant local codes, as applicable, together with the additional requirements referred to in this Specification and Drawings, whichever is the more stringent and acceptable to the Engineer.
- C. In the adoption of standards and requirements, the Contractor shall take the following precedence:
 - 1. Engineer's decision;
 - 2. Local codes of practice;
 - 3. Drawings;
 - 4. Specification;
 - 5. International standards and requirements.

1.03 SUBMISSION

- A. All technical submissions shall be approved by the Engineer prior to the respective stages of construction.
- B. As a minimum requirement, the submission shall include the following:
 - 1. Equipment submission with manufacturer's data;
 - 2. Sample submission;
 - 3. Shop Drawings showing the co-ordinate routing of air terminations, down conductors bonding to re-bar and foundation earth terminations, methods of fixing etc.
 - 4. Builder's works requirement.
 - 5. Proposal on testing procedures and report format for testing of the Lightning Protection System.
 - 6. Detail of the Contractor's installation Professional Engineer who supervise and endorse the installation for occupation permit application.

2.0 PRODUCT**2.01 AIR TERMINATION**

- A. The Contractor shall supply and install an air termination system consisting of continuous horizontal conductors.
- B. The conductors shall comprise of minimum 50sqmm Stranded Bare Copper unless otherwise specified, located as shown on the Drawings and securely fixed in place to the building structure. Wherever possible, the horizontal conductors shall be continuous lengths.
- C. Where saddled to masonry, the fixing screws shall be set in expansion type plugs contained in properly formed holes.
- D. All roof conductors are to be secured at intervals not exceeding 900mm.
- E. The Drawings showing the various roof levels of the building indicate the general arrangement and layout of the air termination system. The Contractor shall ensure that the whole of the air termination system is installed over its total route of the roof areas maintaining absolute electrical continuity.
- F. Provision shall be made with suitable fittings to allow for expansion and contraction of the horizontal conductors.
- G. 600mm height vertical copper air terminal shall be provided for the Air Termination network fixing next to masonry material at the highest points and any connection to down conductor.
- H. Air termination on the vertical side of the building above 45m as required by code shall be provided with maximum 30m spacing and minimum 2 points. The Contractor shall co-ordinate the installation detail to allow for bonding of the curtain wall to the embedded down-conductor re-bar to Engineer satisfaction and comply with BS code requirement. All additional materials and installation as required shall be included in the Contract.

2.02 DOWN CONDUCTOR

- A. The down conductor routes shall be embedded in column as indicate on drawing and shall be as direct as possible.
- B. The bonding conductor at roof conductor shall be of soft annealed copper strip minimum size 25mm x 3mm or 50 sqmm Cu cable. Where the conductors penetrate the roof, the holes shall

be effectively sealed and waterproof with proprietary sealant to the approval of the specialist roofing contractor.

- C. All exposed metal running vertically external to the structure shall be bonded to the 50sqmm Stranded Bare Copper down conductor. This shall be included but not limited to curtain wall frame, pipes, ducts and other metal components running through the Buildings.
- D. The down conductors shall be run according to the route as shown in the Drawings or as required to BS code requirement.
- E. The Sub-Conductor shall ensure that the proper material and equipment are used in accordance with the manufacture's recommended installation.
- F. Lightning protection system shall employing 50sqmm Stranded Bare Copper as down conductor as per Drawing if specified.

2.03 JOINTS AND BONDS

- A. Stainless steel connection plates shall be provided for termination of exposed copper conductors to steel rebar down conductors concealed in structure. All joints and bonds shall be soundly secured and shall be of low resistance. The cross-sectional area of the material used e.g. Copper shall not be less than the main conductor (i.e. 25mm x 3mm) unless otherwise specified.
- B. Where possible, joints shall be kept as few as possible. All joints shall be carried out with manufacturer's recommended compress type clamp. Two (2) screw minimum shall be provided for each joint.
- C. Bonding Points shall be carried out with manufacturer's recommended sets. Customer's self-made items are not acceptable.
- D. Joining of dissimilar metals shall be protected from moisture by applying recommended compound on the material. Bi-metal joint shall be provided where dissimilar metals are used.
- E. All junction and bonding clamps shall be brass/phosphor bronze material.

2.04 EARTH TERMINATION

- A. Down Conductor will be bonded to ring conductor installed in buildings' foundation raft after Copper Test Link by 50sqmm Stranded Bare Copper Conductor at the ground level along the perimeter of the building to comply with IEC 61024-1-2.
- B. The maximum permissible earth resistance of the Lightning Protection System shall be 10 ohms. Testing earth electrode shall be provided for earthing test.

3.0 EXECUTION

3.01 METALLIC CURTAIN WALL BONDING

- A. All elements of the façade shall be directly earthed to the structure for the purpose of lightning protection. The Contractor shall make himself aware of the requirements under the latest revision of BS latest code and IEC 61024-1-2. All necessary connections, conductors, earthing connectors etc shall be deemed to be included in this Contract.
- B. The Contractor shall co-ordinate with the Curtain Wall Supplier/Contractor for the exact interface and bonding requirements. The curtain wall is to be electrically continuous and the

installation shall comply with BS EN 62305. Tests shall be carried out by this Contractor to the satisfaction of the Engineer to ensure electrical continuity as stipulated in the code.

- C. Lightning protection bonding terminals along re-bar down conductor shall be provided by the Contractor at the lowest levels and roof levels for bonding with curtain walls. Intermediate bonding terminals shall be provided at an interval of not exceeding 30m apart at each of the vertical intervals of each down conductor.
- D. As a general practice, bonding points shall be provided and located on the internal face of the claddings. A conductor shall be provided and installed by the Contractor for lightning protection bonding at the down conductors.
- E. The Curtain Wall Supplier/Contractor shall be required to confirm his details on the lightning protection bonding of curtain walls. It is the responsibility of this Contractor to ensure all details (both locations and quantity) agreed complied with BS latest code.
- F. All metal cladding components including panels, glazing frames, mullions, transoms, fixings and support structures shall be fully bonded electrically to ensure electrical continuity of the building development.

3.02 EQUIPMENT/STRUCTURE BONDING ON ROOF & OTHER EXTERNAL AREA

- A. The Contractor shall be responsible for bonding of all metal equipment/structure on roof and other exposed external area on flat roof and ground level, complete cabling by means of 25 x 3mm copper tape or 50sqmm Cu cable up to the termination point provided by respective Contractor. Bonding within the equipment for maintaining electrical continuity of all metal components will be provided by the respective work in the Contract.
- B. All metallic projections, chimneys, vent pipes, cooling towers, railings, antenna masts, fuel tanks, etc. on or above the main surface of the roof and other external areas shall be bonded to and form the part of the air termination network.
- C. For equipment with plan area above 100sq.m, bonding shall be provided at distance not more than 30m apart equally spaced along the perimeter of the equipment.
- D. All bonding shall be to the nearest down conductor by most direct route available.

4.0 TESTING & COMMISSIONING

- A. The Contractor shall arrange with the Engineer for inspection and testing of lightning conductor system. Before the joint testing, the Contractor shall have conducted his own inspection and testing to ensure that all requirements are met as specified. Test report certified by Contractor's installation Professional Engineer shall be submitted to the Engineer. All equipment, transportation, manpower and other necessary costs for the joint inspection and testing shall be borne by the Contractor.
- B. The system shall also be tested at not greater than twelve (12) months intervals for earth resistivity, resistance to earth of the electrodes and electrical continuity of the system during the course of building construction and DLP. The results of these tests shall be by the Contractor's installation Professional Engineer compiled in report prepared by the Contractor.
- C. The Contractor shall supply facilities for the recording of the test results referred to above, arranged in such a manner that comparisons can be readily made with earlier readings.

- D. The Contractor shall submit a detailed layout drawing showing the positions of testing carry out on site.
- E. The record sheet and layout drawing shall be kept on site at all times during the course of construction.
- F. The Contractor shall carry out monthly inspection on the lightning protection system including the earthing pits to ensure that the system is in good working order.

SECTION E 11**TESTING, COMMISSIONING, INSPECTIONS AND CERTIFICATIONS****1.0 GENERAL****1.01 WORK INCLUDED**

- A. General - The Contractor shall completely test and inspect all systems in accordance with the specifications and drawings. The Contractor shall certify that all systems are in complete working order prior to turning over to the Employer.
- B. At least 30 days prior to testing or commissioning any system, the Contractor shall furnish the following information for each system to process to the Engineer for review.
 - 1. Testing procedure and details as well as the relevant report forms to the Engineer for approval.
 - 2. Type of instruments to be used.
 - 3. Manufacturer of instruments
 - 4. Calibration methods for instruments
 - 5. Operating instructions for instruments
 - 6. Accuracy and tolerances of instruments
- C. Submit, within 90 days from the commencement of the Contract a detailed and comprehensive installation completion/start-up/testing schedule, identifying all work and suppliers to be involved. Update the schedule and resubmit for review, on a monthly basis, during the course of commissioning. If found to be unacceptable, revise the schedule and the construction forces to suit the reviewed scheduled.
- D. The Contractor shall employ a team of competent and experienced personnel to carry out all testing and commissioning works. If it is the opinion of the Engineer that the testing and commissioning are not properly executed by the Contractor's own staff, the Contractor shall employ a qualified independent Testing and Commissioning Specialist to carry out this part of the Works, when directed by the Engineer. The cost of employing this Testing and Commissioning Specialist shall be borne by the Contractor. Supply the following details regarding the proposed firm for approval:
 - 1. Principle representative and qualifications
 - 2. Proposed personal and relevant project experience
 - 3. Previous similar assignments and references
 - 4. Scope of work to be undertaken
 - 5. Company resources and equipment
- E. All equipment site testing and commissioning shall be carried out by manufacturer's qualified personnel as required.
- F. All test shall be witnessed by Engineer.
- G. All tests specified in this specification and BOQ are minimum requirement. Test specified in all other section shall be included in the Contract. The Engineer may request and include any test as required without time and cost implication.
- H. Draft of manuals shall be submitted for Engineer review in advance of testing to allow the Engineer to familiarise with the equipment manufacturer's recommendation. Final draft

manuals must be submitted for the Engineer's review before Taking Over Certificate is prepared.

1.02 CO-ORDINATION

- A. Meet the requirements of the General Instructions
- B. Co-ordinate the work of this Section with all other Divisions to ensure complete and operational mechanical systems at completion of this work.
- C. Appoint a single person as Commissioning Coordinator who shall be responsible for progressing the commissioning activities for all work in the Contract.
- D. Review the intent of the project and the intended operation of systems with the Engineer before proceeding with commissioning.

1.03 GENERAL TESTING

- A. It shall be the responsibility of this Contractor to furnish all testing equipment and labor necessary to perform the following test:
 - 1. After wires or cables are in place, but before being connected to devices and equipment, the system shall be tested for shorts, opens, intentional and unintentional grounds by means of wires in conduit that are shorted or unintentionally grounded shall be replaced.
 - 2. A voltage test on the last outlet of the branch circuits shall be spot checked or as directed by the Engineer and the potential drop shall not exceed 2%. Voltage drops for panel and large feeders shall not exceed 3% hence the total voltage drop for a feeder and any branch circuit shall not exceed 5% of the service voltage. The test shall be made under specify load or its equal.
 - 3. Any wiring device, or electrical apparatus in this contract, if grounded or shorted on an integral "line" part, shall be removed and the trouble corrected.
 - 4. When required, complete test and inspection records shall be made and incorporated into a report for each piece of equipment tested. All readings taken shall be recorded. Four (4) copies shall be submitted to the Engineer for approval.

2.0 PRODUCTS

2.01 TEST EQUIPMENT AND MATERIALS

- A. The Contractor shall provide all testing instruments, equipment and all materials, connections etc. required to perform tests in accordance with these specifications.

3.0 EXECUTION

3.01 WIRING TEST

- A. All wiring and cable tests shall be made before any circuits, main switch, motor, transformer or line is energized.

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- B. Tests shall be made for continuity, identification and absence of shorts and grounds for each conductor. Both ends of a given conductor shall be identified alike. Before circuit terminal connections are made, continuity and identification of wiring shall be checked by means of a DC test device using a bell, light, meter, or buzzer.
 - C. Insulation test shall be make at the following values:
 - D. 230 Volt Wiring at 500 Volts DC
 - E. Insulation resistance between phase conductors and ground shall not be less than the minimum requirements of 200 mega-ohms.
 - 1. Wire terminations are not to be made to equipment (motors, MCCs, bus ducts, etc.), until that piece of equipment has been tested and verified as specified in this sections.
 - 2. Test motor feeders with motors disconnected, but with circuit breakers, switches or starters in the circuit opened so as to include only that portion of the feeder it is desired to test.
 - 3. Test lighting feeders with the circuit breakers and panelboards connected but with lighting branch circuit breakers or switches open so as to include only the feeder circuit desired to test.
 - F. Contractor shall correct or replace any circuit which is defective or grounded and he shall also correct all other troubles encountered by these tests. All defects whether due to faulty workmanship or material furnished by the Contractor shall be corrected under this section at the Contractor's expense in a manner acceptable to the Engineer.

3.02 LIGHTING TEST

- A. Check all lighting fixtures for proper operation. All Contractor supplied fixtures to be 100% operable at no additional cost to the Contract.

3.03 MOTOR TEST

- A. All 400 volt motors shall be individually tested for insulation resistance using 1000V DC. All 230V motors shall be tested with 500V DC in a similar manner. The minimum resistance to ground shall be 2000 mega-ohm (corrected to 50 degrees C). The Contractor shall record the ambient temperature of the motor and submit this value along with insulation resistance value. For motors from 7 1/2 to 20 HP, Contractor shall submit Dielectric Absorption Ratios. For motors above 20 HP, the Polarization Indexes of the motor shall also be submitted.
- B. Make the following checks on all motors prior to start -up:
 - 1. Check motor name plates for H.P., speed, phases and voltage. Verify proper wiring.
 - 2. Check shaft for freedom of rotation.
 - 3. Verify that the motor is properly lubricated prior to energizing.
 - a. Contractor to furnish a proper sized heater for each overload relay. Notify the Engineer prior to installation of the motor full-load current rating, the number of overload relays, the starter catalog number, and the heater catalog number. The Engineer will aid in the selection of the proper heaters if requested, provided all pertinent information is given.
 - b. Make the following tests on all motors during or immediately after start-up:

- 1) Check for proper shaft rotation.
- 2) Check motor for smooth operation (vibration).
- 3) Take a current reading using a clamp-on ammeter. (No-load readings and loaded readings).

3.04 PANELBOARD, BUS DUCT AND M.C.C TESTS

- A. Test all equipment to be operated on the 230V system at 500V DC prior to connecting feeders. A minimum insulation resistance of 200 mega-ohm shall be obtained between all phases and between phase and ground.

3.05 TRANSFORMER (POWER 600V OR LESS) TEST

- A. Insulation tests on transformers shall be as follows:

1. 230Volts Low Side
 - a. Test with 500V DC, low side to ground. 200 mega-ohm shall be the minimum acceptable insulation resistance.

3.06 INSULATION TEST

- A. Insulation test mentioned in this section shall be interpreted as the specific test method of obtaining insulation resistance by applying indicated test voltage for 60 seconds to the equipment or wiring being tested.

3.07 FACTORY TEST

The following items of equipment shall be tested at the manufacturer's works or elsewhere as appropriate prior to installation. In all cases, test certificates shall be submitted in triplicate certify by the Contractor's Engineer.

A. LV Switchboard and Motor Control Centre

1. Type test Certificates indicate short circuit capacity and temperature rise
2. Factory Tests Report on the

unit. B. Generating Plant

1. Type Test Certificate
2. Factory Tests Report on the unit

C. Fuel Storage Tank

1. Hydraulic Test Report endorsed by Contractor and manufacturer

D. MV Switch Board

1. Type Test Certificate
2. Factory Tests Report on the unit.

E. MV/LV Transformer

1. Type Test Certificate
2. Factory Tests Report on the unit

- F. The Contractor shall include for the requirement for witness at manufacturer Factory Test, the Engineer and Employer representative – 2 persons 3 working days (excluding transport time) for tests at USA embassy/Local agreed rate.

3.08 EXECUTION OF SITE TESTING AND COMMISSIONING

- A. The plant shall be inspected and tested during and after installation on site as set out below for compliance with the performances, and ratings as specified.
- B. All tests shall be witnessed by the Engineer's representative at site with at least seven days' notice given prior to any test.
- C. All tests shall be executed and, if not satisfactory, repeated to the satisfaction of the Engineer at no extra cost.
- D. Partial Discharge and Ultrasound testing for Medium Voltage Equipment to locate any high dB readings or any partial discharge. The test shall be performed by specialist Tester completed with conclusive report to record the working condition of the installation and termination.
- E. Infrared Thermoelectric Detection to all MV and LV Main Switch Board, Transformer, Generator and Busduct to locate any hot spot or loose termination. The test shall be performed by specialist Tester completed with conclusive report to record the working condition of the installation and Termination.
- F. At the appropriate stages of the installation, inspection and testing prior to the energizing of equipment, insulation tests shall be made and recorded
- G. Operational tests of all electrical equipment in proper staged phases shall be made and recorded prior to energizing. For example, the battery charger and batteries shall be checked prior to furnishing the DC control power for the circuit breakers. The circuit breaker control shall be operationally checked for all local control, including testing up to interface terminal points for signals and control interconnection to other system or installation, prior to carrying out operational tests of the circuit breaker.
- H. The Contractor shall develop a complete and detailed plan for the site testing of the power supply systems beginning with the incoming breakers and following a logical plan which will allow energization of the system in a safe and secure manner and to interface and co-ordinate with the other electrical and mechanical installations.
 - 1. The Contractor shall provide his own equipment for testing and check the installation to ensure that it complies with drawing and specification and Local Authority's requirements, including the preliminary polarity test and phasing of electrical mains.
 - 2. Test results shall be recorded and certified by Contractor's qualify personnel. Two (2) copies of such report shall be submitted to the Engineer prior to the joint testing.
- I. The Contractor shall be responsible for the surveillance and security of the power systems including padlocking or otherwise maintaining control of the power supply, padlocking of switchgear and circuit breaker units, distribution switchboards, etc. throughout all energization stages of the installation. The Contractor shall co-ordinate with all work to assure no downstream cables or other electrical equipment is energized before tested and before facilities which receive power are ready and secure. The Contractor's responsibility for surveillance and security of the system shall remain in force for each part of the system until such a time that the complete installation is certified complete by the Contractor in writing.
- J. Precautionary measures shall be taken during testing and the method of tests shall be such that no danger to persons or property can occur even if the circuit being tested is defective.

3.09 SITE TESTS

- A. All equipment, cabling, distribution, etc. is electrically and mechanically safe
- B. All interlocks, isolators and door cover securing mechanisms are properly fitted and adjusted
- C. All exposed metal work is properly bonded and earthed in accordance with IEE regulation and statutory requirements and that all connections and points required to be earthed for safety and satisfactory operation are properly earthed in accordance with the manufacturer's requirements
- D. All cables, cores and terminations are properly marked off, secure, properly supported and correctly identified and coloured
- E. All phases, polarities, natural and common connections are correctly switched as required, that power is correctly available at all points and that voltage and frequency at all equipment are correct and in accordance with requirements for correct working.
- F. All supplies are properly fused, or otherwise protected to give satisfactory discrimination and safe disconnection under fault conditions
- G. All conductors are properly aligned and not subject to excessive wear and erosion
- H. All protective covers are properly fitted, all warning and designating labels are correct and in position and the inside of all boxes and cubicles are clean and free of "swarf" and cable strippings
- I. Batteries, if provided, are properly ventilated, installed, connected and fitted, and that battery chargers are working correctly
- J. Insulation resistance of all cabling and equipment is not less than that required by relevant Electrical Installation code.
- K. All instruments and meters are energized with correct polarity and working properly
- L. All fault indications and alarms are working correctly and
- M. All essential equipment fed from battery systems continue to function correctly and without disturbance during all supply failure, restoration and standby sequences.
- N. In addition to all operational tests required for satisfactory completion, the operation of all interlocks, sequences and protection not utilized in normal operations shall be checked to the satisfaction of the Engineer.

3.10 FUNCTIONAL TESTS

Functional test for the system shall be conducted for performance, safety, reliability, maintainability and for compliance with the specified requirements. These tests shall be performed progressively on site in accordance with the Contract programme to verify that the complete installation will meet the requirement of this specification. The list provided below is an indicative minimum of the tests required. The Contractor shall develop full test schedules for approval in accordance with the requirements as spelt out in respective sections of the Specification.

A. General

1. Check correct CT ratio and polarity and correct operation of all protective gear by primary tests and system fault tests to check sensitivity and stability
2. Secondary current injection tests for accuracy of relay operations. Protective gear timing tests as may be necessary
3. Rotational tests on all motors
4. Battery tests on specific gravity, correct output voltage, discharge test and proper functioning of the charging equipment etc.
5. Tests to prove correct operation of all interlocks, tripping and closing circuits, alarm indications, etc. including operation in conjunction with the standby generator for emergency operation of lofts, etc.
6. Phasing tests.

B. MV Switch Board, Transformer, and MV cable

1. Injection Test (Primary and Secondary)
2. Insulation Test
3. Partial Discharge and Ultrasound Test
4. Infrared Thermoelectric Detection
5. Manufacturer Recommended Test

C. LV Switchboard

1. Mechanical tests
2. Continuity and dielectric tests
3. Secondary injection test to re-calibrate all measuring, protect and control circuits and associated components
4. Phase sequence tests on each outgoing units
5. Functional checks, especially on the controlling devices and
6. Infrared Thermoelectric Detection (include power factor correction equipment)
7. Primary Injection Test

D. Cables

1. Continuity test
2. Insulation resistance test and
3. Phasing test

E. Standby Generating Plant

1. Series of test starts and checks on ability to take up the load within the specified time
2. Check that speed variation is within specified limits
3. Voltage regulation test
4. Functional tests of all plant protection features and alarms
5. Temperature rise test
6. Noise level measurement
7. Insulation resistance test
8. Building essential load test and
9. Infrared Thermoelectric Detection.

F. Hydraulic Tests

1. Hydraulic test of 70 kPa for bulk tank for not less than 2 hours
2. Hydraulic test of 70 kPa for pipeworks, valves and fittings for not less than 2 hours.

G. LV Power Distribution System

The following items, where relevant, shall be tested in the sequence indicated:

1. Continuity of ring final circuit conductors
2. Continuity of protective conductors, including main and supplementary equipment bonding
3. Earth electrode resistance
4. Insulation resistance
5. Insulation of site-built assemblies
6. Protection by electrical separation
7. Polarity
8. Earth fault loop impedance
9. Function of all items of equipment and
10. Infrared Thermoelectric Detection

H. Lighting

1. Illuminance / luminance measurements for normal, emergency and battery lightings
2. Illuminance / luminance measurement for battery lights at the end of 2-hour operation
3. Test to establish correct operation of switching control
4. Insulation resistance tests to earth and between conductors before and after fitting of lamps
5. Measurement of leakage current when directed by the Contractor.

I. Lightning Protection System

1. Continuity between air and Foundation earth; and
2. Foundation Earthing

J. UPS

1. Full Test to Manufacturer Recommended Procedures
2. Full load test to verify the total back-up time
3. Infrared Thermoelectric Detection; and
4. Ultrasound Test

K. Extra Low Voltage System

1. Full Functional Test to Manufacturer Recommended Procedure

3.11 AUTHORITIES TEST AND INSPECTION

A. The Contractor shall engage sufficient qualified and experienced site staff to execute the works. Qualified personnel shall be employed to supervise the works if necessary.

B. The services of Professional qualified personnel (Mechanical and Electrical) and other statutory licensed workers shall be engaged to assume full responsibilities for all engineering matters including engineering, submission to Authorities, installation and switching. These personnel shall be available to attend meetings, discussions, inspections, and the like as required by the Engineer and Authorities. Upon completion of the Contract works, the qualified personnel of the Contractor shall furnish Completion and Inspection Certificates with

the same format as required by the respective authority for the respective parts of the works to the Engineer to certify that all the works are in full compliance with the Specification and Drawings.

3.12 FINAL ADJUSTMENTS AND COMMISSIONING

- A. When the entire installation works are completed and all the above checking and testing have been properly carried out, the Contractor shall set to work, regulate and calibrate the entire installation. Particular attention shall be paid to the following:
1. All equipment are silent and meeting the specified noise and vibration levels.
 2. All instruments are correctly calibrated and read accurately.
 3. All control systems are functioning correctly and are properly sequenced, interlocked, and interfaced with other services.
 4. All major plant to be fully commissioned by the respective Manufacturer's qualified field testing and commissioning engineers.
 5. The Contractor shall be aware that the commissioning may need to be carried out after the Taking Over Certificate is issued and after normally office hours, as required by the Employer.

3.13 TAKING OVER

- A. The following procedures shall be adopted prior to taking over the installation:
1. All preliminary testing, checking, adjusting and balancing of the installation shall be carried out before forwarding notification that the installation is considered to have reached Practical Completion.
 2. After inspection, and when the Engineers is satisfied and agrees that the installation is ready for taking over to the Employer, the plant shall be finally commissioned and Installation Manuals together with as-built drawings shall be provided as specified.

3.14 POST COMPLETION PERFORMANCE VISITS

- A. Visit the site with the Employer's representative each month after project completion for a minimum period of two days until the end of the project warranty period.
- B. Review the operation of the system.
- C. Correct any operating problems, if problem is related to warranty issues.
- D. Prepare re report for inclusion in the Operating Manuals of the problems and issues that have arisen and the corrective action(s) recommended and implemented.

SECTION E12 PARTICULAR SPECIFICATIONS

CLIMATIC CONDITIONS

The Contractor/Constructor is deemed to be familiar with climatic conditions prevailing in Peshawar and to be aware of the high temperature up to 50°C, max. The Contractor/Constructor in submitting a tender will be assumed to warrant that all materials and items of equipment are suitable for continued use and/or operation in the various climatic conditions encountered.

STANDARD AND STATUTORY REGULATIONS

The works shall be carried by a registered Contractor/Constructor approved by the relevant authority for each particular classification of work. All material and workmanship shall conform to the specifications and to the following:

REGULATION

Not with standing anything to the contrary contained herein pertaining to this installation, it shall be the Contractor's/Constructor's responsibility to ensure that all the works are in strict accordance with the following statutory obligations, regulations and specifications together with any amendments made thereto:

- a) British Standards Institution or other approved international standards.
- b) 17th Edition of the UK I.E.E. Wiring Regulation.
- c) Building Control Act and Regulations
- d) Building Energy Code of Pakistan
- e) Electrical Act, 1910
- f) Electrical Rules,1937
- g) Any other local authority having jurisdiction

SCOPE OF WORK

The work shall include furnishing all materials, labors, plant and supporting services for complete supply, installation, testing and commissioning of the following:

- a. Primary underground service line as required for the project.
- b. Distribution equipment including LT Cabling, Motor Control Unit Panel (MCU) and Distribution Boards.
- c. A system of interior lighting and power wiring including feeders, circuits, sub-circuits and point wiring.
- d. A system of interior Luminaries for common areas.
- e. Switches and small power sockets.
- f. Earthing System.
- g. PVC pipes, cable ducts and other raceway for power system.
- h. Complete testing and commissioning of the Entire Electrical System installation.

SAMPLES

The Contractor/Constructor shall arrange and submit for approval one set of labeled samples as follows:

- Conduits/Pipes, fittings and supports.
- Wires and cables
- Switches and sockets
- Light fixtures
- MCU shall be inspected by Engineer prior to delivery at site

The Consultant (Engineer reserved the right to require samples which show the fabrication techniques and workmanship of component parts, and the design of accessories and other auxiliary items, before any installation work proceeds.

The Contractor's/Constructor's shall submit to the Consultant/Engineer for endorsement manufacturer's specification and installation instruction for trade products.

SHOP & AS-BUILT DRAWINGS

The Contractor/Constructor shall submit for the Consultant/ Engineer's approval 02 sets of shop drawings in a timely manner according to the construction Program. Within 14 days of being notified of the intent to award the contract, the contractor shall submit the submission program for approval. The submission program shall include the following details:

- List of shop Drawings
- Proposed submission dates
- Proposed approved date to meet the installation and Authorities submissions program.

The shop drawings must be of sufficient detail to satisfy the installation requirements to the approval of the Consultant/Engineer. The shop drawings shall show all location of equipment, cable trucking/tray routing, conduits, and joints for wiring, anchors, supports, hangers, test points, measurement instruments, and the like. As built drawings shall be similarly submitted at Completion.

On completion of work contractor/constructor will prepare As-built drawings for all works including every electrical items/system and would submit at least 04 sets of drawings in hard copy form and one CD for soft document.

CABLE SUPPORT SYSTEM

Cable Support System

Steel Conduit:

Conduits shall be of heavy gauge steel conforming to British Standard. They shall be solid drawn or seamed by welding. Both ends of the conduit shall be screwed. Conduits shall be galvanized to Class 4 type of BS 4568:1970 and be of approved reputable manufacture. Adequate protection against corrosion shall be applied to both conduit interior and exterior. Flexible conduits shall be of mild steel complying with BS 731: Part 1:1952. Where the situation requires, they shall be PVC covered.

Fittings:

Fittings shall be those intended for use with screwed conduits and shall comply with BS 4568: Part 2:1970. However, bends, elbows and tees shall not be installed. Adapters used with flexible conduits shall conform to BS 731: Part 1:1952.

Circular Boxes:

Circular boxes shall be of malleable cast iron, galvanized and of standard pattern with spout(s), cover plates of similar make complete with brass fixing screws.

Rectangular Boxes:

Rectangular boxes (adaptable boxes) shall be of mild steel not less than 2.0 mm gauge and galvanized, with lids of the same gauge with brass fixing screws.

Boxes for Accessories:

Boxes for accessories shall be suitable for surface mounting or recessed mounting. Surface mounted boxes and accessories shall be of metal clad pattern. Recessed boxes and accessories shall be complete with insulated molded type cover plates.

PVC/PVC Conduit:

Conduits shall conform to BS 6099: Part t and shall be heavy gauge of wall thickness of 1.9 mm rigid tubes which are unscrewed without coupling and with plain ends. All conduits used shall not be less

than 25 mm in diameter. PVC conduit mounted outside building will not be accepted. PVC conduits shall not be used where liable to mechanical damage.

PVC/PVC Conduit Accessories:

Accessories used for conduit wiring shall be of an approved type complying with BS 4607. Plain conduits should be joined by slip type of couplers with manufacturer's standard sealing cement. PVC-switch and socket boxes with round knockouts are to be used. The colors of these boxes and the conduits shall be the same. Standard PVC circular junction boxes are to be used with conduits for intersection. Tee-junction angle junction and terminal. For the drawing-in of cables, standard circular through boxes shall be used.

All jointing of PVC conduits shall be by means of adhesive jointing. Adequate expansion joints shall be allowed to take up the expansion of PVC conduits.

Cable Tray and Trunking:

Metal trucking shall comply with BS 4678 and shall be manufactured in minimum lengths of 2m from 16 SWG GI sheet. Covers are to be held in place by screws. Conduit entries to trucking shall be made with couplings and brass male bushes. Turnings shall not contain more cable than allowed by the space factors described in the IEE Regulations.

All supports and hangers shall be of hot-dipped galvanized mild steel construction to BS 729:1971 Part 1 with min. coating thickness of 85 and 210 for indoor and outdoor installation respectively. All bolts and nuts shall be electroplated with zinc or cadmium to BS 3382: Parts 1 and 2 with min. plating thickness of 25.

Cable tray shall be of perforated type and constructed of minimum 1.6 mm hot dipped galvanized mild steel. Cable trays shall be supported by electro-galvanized 'U' channel with galvanized threaded rod for indoor suspended tray and hot dipped galvanized for area subject to weather.

Cable trucking shall be manufactured from 1.6 mm minimum electro-galvanized sheet steel to BS 1449: Part 1:1983 finished in oven-baked electro-statically coated epoxy powder coating Cable trucking, subject to weather, shall conform to BS 729, hot dipped galvanized and painted. External flanges shall be provided to avoid ingress of water.

Conduit Installation:

The whole conduit system shall be installed to comply fully with IEE Wiring Regulation.

1. PVC conduit Electrical Grades shall be used for concealed wiring.
2. PVC pipe class D/RCC pipe class A/GI pipe light grade for underground wiring.
3. Flexible PVC conduit with appropriate glands shall be used for termination of all connections to recessed light fixtures in false ceiling.
4. Flexible steel conduit, to BS 731/6099, shall be used for final connection to motor and other equipment subject to vibration and movement.
5. Under floor runs of conduits shall have at least 50 mm of concrete cover and be well sealed against the ingress of moisture.
6. All accessories fittings and glands used for outdoor installation shall be corrosion proof and weatherproof type.
7. Factory-made bends, joints, elbow; riser, tee, reducer and accessories with same material shall be provided throughout the installation for tray and trucking.
8. Copper earth link bar shall be fixed at every joint of the cable tray and trucking run.
9. All hangers for cable trays/trucking shall be installed at 1 meter intervals.

CABLE AND WIRING

Cables and Wiring

600/1000-Volt PVC, XLPE/PVC, PVC/PVC, XLPE/SWA/ PVC and PVC/SWA/PVC Cables

Cables shall utilize standard copper conductors only. All cables shall be made in accordance to the following standard. BS 6346:1997 BS 7870-3.1:1996 BS 6004:1995. Insulation colors and wire sizes shall be in accordance to IEE Regulations. PVC insulated, PVC sheathed copper conductor cable for internal power distribution.

Circuit and sub-main wiring shall have an adequately sized earth continuity conductor. The maximum continuity resistance from any point of the installation including the earth continuity to the earth electrode shall not exceed one Ohm.

Wiring shall be continuous between terminations and use of connectors or joint will not be allowed (joints in point to point cable runs are prohibited). Cables for 3 phase 4 wire system shall be colors coded red, yellow, blue for phases, black for neutral and green/yellow for earth. For flexible cords the minimum size shall be 1.5 sq. mm. Flexible cords connecting into lighting fittings shall be 3 core heat resistant Butyl' rubber insulated.

Wiring to light points, 5A, 13A & 15A Power Outlets:

450/750-volt grade PVC insulated/sheathed copper conductor cables single multi core shall be used for circuit wiring of light points and sockets. Power wiring shall be kept separate and distinct from lighting wiring. All wiring must be done from distribution boards. A separate earth wire will run all along the power wiring and will be properly earthed.

Terminations and Cable Glands:

Cables entry into the main or distribution switch boards, shall be through approved glands adequately sized for all cables. All accessories, fittings and glands used for outdoor installation shall be corrosion proof and weatherproof type to approval. Conductor connections and terminations shall be made with compression ferrules and lugs to BS 91 using a hydraulic crimping tool. IP class of cable glands should be same as DB/MCU

Installation methods:

Unless otherwise specified, all outdoor wiring shall be PVC/SWA/PVC for core single core cable direct buried in the ground and heavy duty PVC or RCC pipes under driveway, pavement, hard core area etc.

ACCESSORIES

Accessories

Switch and Socket Outlet Boxes:

Gang outlet boxes shall be used where two or more devices are grouped in one location. These outlet boxes shall be made of 1.63 mm. sheet steel with protective black enamel paint coating inside and outside the box.

Before applying black enamel, the cleaned surface of sheet steel box shall be given lead oxide antirust coating inside and outside the box. The cover of such outlet box shall be approved amazonite, Teflon, Bakelite or plastic. Where switch and socket outlet boxes are to be installed on surface in an exposed conduit wiring system, these shall have, in addition to the protective coating, color paint coating to match the color of the walls etc.

Weatherproof enclosure shall be of the high impact water resistant to IP 65. The isolator provided shall be complete with a lockable device.

Switches:

Switches controlling light and fan points shall be single pole. These shall be made of Bakelite or plastic and suitable for flush mounting in an outlet box. Where more than one switch is to be installed at one location, the switches are formed in gangs. Switches shall be rated at 10 amperes (Logic Grids), 250 Volt. Switches for external use shall be of weatherproof construction with IP 65 rating.

Switched Socket Outlets:

Only switched socket outlets shall be used Socket and plug unit shall be 3-pin 13 Amps universal for power outlets at 250 Volts and 220/115 volt for shaver socket outlet These shall be made of Bakelite and suitable for mounting flush with wall or column or for surface mounting as required. Where socket and switch units are installed outdoor, or in a damp or wet area, they shall be IP65 rated.

Installation of Switches and Socket Outlets:

Switches and socket and plug units shall be installed flush in the wall. All switches shall be installed at a height of 1.2m from finished floor level- Socket plug and switch units shall have its centerline at 450mm above finished floor level.

LIGHT FITTINGS AND FIXTURES

Fluorescent Light Fixture:

Fluorescent light fittings shall be supplied complete with the lamps and ballasts of required wattage. The fluorescent tube shall be TL5 color 84 type, totally enclosed and suitable for 230 volts, 50Hz single-phase supply. The wiring diagram along with the voltage, wattage and current values shall be printed on the body of the ballast. The internal wiring of the fluorescent light fittings shall be completed at the factory, with heat resistance wires having a minimum cross-sectional area of 1.5 sq. mm.

Lamp Holder:

The Lamp holders shall be bi-pin, spring loaded of robust construction and designed to retain positively the lamp caps independently of the contact springs. Contact springs shall be of phosphor bronze material.

Bracket Fans:

Fans, to BS 5060, shall be of the capacitor type, specially designed blades for quiet operation, wide air throw, 3 speed adjustment, powder coated, Die cast aluminum body, low energy consumption, works even on low voltage, double "Z" Ball Bearings, High Grade Copper Wire & Silicon Steel Sheet, 3-StageUp and down Adjustment and remote control option.

LOW VOLTAGE SWITCHGEAR

Motor Control Centre (MCC):

Motor Control Centre should be in compliance with BS 5486/4752, shall be of the cubicle type, totally enclosed, dust-proof: floor/surface/flush-mounting type, fabricated from 14 gauge sheet steel, derusted degreased, rust-proofed, painted with two coats of enamel, with hinged covers, and metal safety plates. The equipment shall be rated 400 volts, and be suitable for operation on the utility supply. Boards shall be factory assembled ready wired, and shall be complete with adequately rated electrolytic copper phase, neutral, and earth bus bars; suitable clamps, jointing and termination accessories, line-up terminals, earthing bolts, etc.

Miniature circuit breakers (MCBs) and molded case circuit breakers (MCCBs), to IEC 60947-2, shall be of the molded-type with operating lever protruding through the metal safety plate Switch-fuses and bad break switches (AC 23), m BS 5419, incorporating HRC fuses, to BS 88, shall be of the heavy duty, metal-clad type, complete with all accessories. Motor starters, to BS 4941, shall be of the push-button, magnetic-contractor (AC-3) type, with single-phasing prevention, ambient-temperature compensated, overload relays, and with Type 2 short-circuit protection to IEC 60947.

Indicator lights, push buttons, etc. - to BS 4099 IEC 60947, shall be rated 250 V, and CTs shall be of Class 0.5 for tariff metering purposes, and 1.5 for indicating purposes The CTs shall have suitable burden and over-current (saturation) factors.

The short circuit ratings (dynamic. and thermal) of all switch gear assemblies shall be equal to or greater than the SC level (IEC 947-2, ICU at 415V). The KA rating for lighting circuit shall be not less than 10 KA and for power it shall be 15 KA. The characteristics of the protective devices shall be such as to provide selective discrimination. All switchgear will be rated at 50 °C with $IC_u = 100\% IC_s$.

Motor-starter feeders with MCCB back-up protection (type 2 to IEC 947) Motor - protection (AC3-duty) magnetic contactors, 3-pole differential-type thermal overload relay with "hand/auto-reset" "on/off" push buttons, "hand/off/auto" selector switch, "on/off/trip (Definite overload)" indicating lights, 2 CIO space auxiliary contacts, CT and ammeter (with overload/starting range). PTC thermistor relay (19kw & larger), remote-control/indication provisions, remote audio/visual alarm for each outgoing circuit.

EARTHING

General:

The contractor/Constructor shall install a complete earthing system. The contractor/Constructor shall install a complete earthing system comprising a main earth electrode system, main earthing conductor, earth bars (in MCU etc.), earth continuity conductors, potential equalizing bars and potential equalizing (bonding) conductors.

Main Earth Electrode System:

In the vicinity of the Motor Control Unit, Motor and Pump, an earth electrode system shall be installed by the Contractor/Constructor to achieve less than one ohm resistance to earth. If the required resistance cannot be achieved in the specified configuration, additional ground earthing plate shall be installed and added to the system, provided that they are installed not less than 5 meters away from the existing earth plate.

It shall be constructed of 610 mm x 610 mm x 6 mm copper plate exothermically (Cadweld) welded to (minimum 70 sq. mm.) bare copper earth wire laid horizontally 7500 mm under the ground surface.

Main Earthing Conductor:

Main Earthing conductor shall comprise two 70 Sq mm copper conductors cadwelded to the main earth electrode and connected to the main earth bar with an approved type double crimp double hole compression hugs. The conductors shall be labeled with a permanent label: "Main Earthing Conductor - do not remove"

Main Earth Bar:

Main Earth Bar shall consist of a (minimum 50mm wide 6mm thick) high conductivity tinned copper bar of a suitable length (minimum 200 mm), installed next to the MCU. The bar shall be easily accessible, wall mounted over the cable duct on approved insulating spacers installed. . The bar shall be predrilled card equipped with necessary (cadmium plated) bolt / locking washer / double nut arrangement for connection of the earthing conductors.

MCUs, Motor Earthing Conductors:

The Main Earth Electrode shall be connected to the MCU & Motor with two insulated 70 Sq.mm copper conductors. The conductors shall be labeled with a permanent label at both ends: "Do not remove - Main Earthing Conductor".

Potential Equalizing Conductors:

Insulated potential equalizing conductors of adequate cross-section shall be run from the Main Earth Bar to all bonded to earth structures and potential equalizing bars in various arias.

Earthing of Metallic Parts:

All metal parts including pipes, pumps and motor shall be ground by minimum 70 sq. mm PVC copper conductor.

MECHANICAL WORKS

SECTION M 01**MECHANICAL SPECIFICATIONS****PUMPING EQUIPMENT****Description**

All pumping units shall be provided complete, as indicated on the Drawings and specified herein, including pumps, motors, anchor bolts, controls, and necessary appurtenances.

Products General

Pumps and drives shall be rated for continuous duty and shall be capable of pumping the flow ranges specified in the Particular Specifications. The pumps shall not overload the motors for any point on the pump performance characteristic curve within the limits of stable pump operation, as well as throughout the entire pump operating range. The service factors for the motors shall not be applied when sizing the motors. To insure vibration-free operation, all rotative components of each pumping units shall be statically and dynamically balanced. Excessive vibration shall be sufficient cause for rejection of the equipment. The mass of the unit and its distribution shall be such that resonance at normal operating speeds is avoided. In any case, the amplitude of vibration as measured at any point on the pumping unit shall not exceed the limits set forth in the latest edition of the Hydraulic Institute Standard. All parts of each pump shall be designed to withstand the stresses that will be imposed upon them during their handling, shipping, erection, and operation. The completed units, when assembled and operating, shall be free of cavitation, vibration, noise, and oil or water leaks over the range of operation. All units shall be so constructed that dismantling and repairing can be accomplished without difficulty. All components of the pumping systems shall be provided by a single pump manufacturer/Supplier such that pumps, drive motors, system controls and accessories shall be the unit responsibility of the pump manufacturer/Supplier.

Pump Construction

This specification covers pumps which may be broadly classed as a centrifugal type. The general requirements shall apply to the applicable types unless otherwise described or modified by the individual pump specifications which are included later in this section.

Installation and Start Up

The Contractor shall arrange to have the pump manufacturer or supplier of the equipment provided under this section, furnish the services of competent factory-trained personnel to supervise the installation and initial operation and this allowance should be included in the price of the equipment.

Instruction

After the equipment has been installed, tested, adjusted, and placed in satisfactory operating condition, the Contractor shall provide the services of a representative of the manufacturers to instruct the operating personnel in the use and maintenance of the equipment. At least one week prior to commencement of the erection period, the Contractor shall give the Engineer formal written notice of the proposed time of instruction. The Manufacturer shall provide a level of instruction which is adequate to train the Employer's personnel regarding use of the equipment. During this instruction period, which shall be for not less than 2 working weeks, it shall be the responsibility of the Manufacturer to answer any questions from the Employer's operating personnel.

Shop Testing

Each major component of the pumping equipment shall be subjected to a complete witnessed shop test as specified herein. Certified test reports, in triplicate, shall be submitted to the Engineer. No equipment shall be shipped until receipt of the Engineer's written approval. All costs for the shop tests shall be borne by the Contractor and shall be included in the Contract Rates.

Certified laboratory reports shall be submitted indicating the percentage of nickel iron in the wetted portions of the pump.

Each assembled pump and drive unit shall be shop tested to determine the following characteristics;

- a) head-capacity curve
- b) brake power curve
- c) efficiency curve
- d) balance
- e) vibration
- f) bearing temperature
- g) percent slip at motor full-load torque
- h) load test at 115 percent of motor full load torque and minimum load speed of 96 percent of motor speed with normal field excitation and determination of the motor current; output speed; and drive excitation.

All tests shall be performed in accordance with the latest Hydraulic Institute Standards.

If any pump does not meet the specified requirements, it shall be modified by the manufacturer to meet the requirements of the Specifications and shall be retested in accordance with the provision of the Specifications. All costs of retesting shall be borne by the Contractor.

Each motor shall be subjected to the manufacturer's recommended shop tests in accordance with the requirements of the applicable sections of ANSI, and NEMA test Standards.

Field Testing

Following completion of the installation and satisfactory start-up of the equipment, the Contractor shall provide the services of the pump manufacturer's representative to operate each pumping unit over the entire specified range. The operation, over the entire speed range, shall be free of cavitation or excessive vibration or noise.

Vibration shall be checked and recorded. The full speed vibration of all pumps shall be within acceptable limits as set out in the latest edition of the Hydraulic Institute Standard. Excessive vibration shall constitute sufficient cause for rejection of the equipment.

Each pump performance shall be documented by obtaining concurrent readings showing motor voltage and amperage, pump suction head and pump discharge head. Readings shall be documented for at least three pumping conditions to ascertain the actual pumping curve. One test shall be at shutoff head. Each power lead to the motor shall be checked for proper current balance.

Bearing temperatures shall be determined by a contact type thermometer. A running time of at least two hours shall be maintained at the maximum specified operating head.

In the event any of the pumping equipment fails to meet the above test requirements, it shall be modified and retested in accordance with the requirements of these Specifications.

Spare Parts and Lubricants

The Contractor shall provide spare parts and lubricants for all mechanical equipment provided under this project. The quantity of spare parts and lubricants shall be sufficient to cover all items necessary to perform all scheduled routine maintenance for a period of 2 years as recommended by the equipment manufacturer or specified in the operation and maintenance manuals. The spares shall be boxed or packaged for long term storage and shall be plainly marked for identification and reordering.

SUBMERSIBLE PUMP (TUBEWELL)

The bidder should ensure the following,

- Each pump shall be designed to successfully operate at a rated duty point. The pump shall achieve minimum pump efficiency at the design point not be less than 70%.
- Minimum gross efficiency of pump and motor should be 50% or more. The pump's nominal speed shall be equal to or less than 3000 rpm.
- Pump is to be tested for its performance and certificate as per ISO-9906 class 2B Standard.
- The head-capacity curve shall have a single flow rate for each pumping head value and have a continuously rising head characteristic from the specified design point to shut-off.
- Pump should have minimum operational life of 5 years.
- Pump should comply following safety standards.
 - EN ISO 12100 for checking the safety and carrying out risk assessment
 - EN 809 for checking the safety of the Borehole Submersible Pump

Material

The Bidder should ensure the following parameters to ensure metallurgical part for improved pump life.

- The pump shall be of at minimum, the following grades of materials:

Component	Material	Standard
Casing/Diffuser	Stainless Steel	304
Impeller	Stainless Steel	304
Split cone	Stainless Steel	304
Split cone nut	Stainless Steel	304
Stop Ring	Carbon/ Graphite PTFE	
Neck Ring Retainer	Stainless Steel	304
Strainer	Stainless Steel	304
Suction Interconnector	Stainless Steel	304
Pump Shaft	Stainless Steel	431
Coupling	Stainless Steel	304

Strap	Stainless Steel	304
Cable Guard	Stainless Steel	304
Neck Ring	SUS304+ NBR	
Nut	Stainless Steel	304
Bearing	NBR	

Each stage casing shall have replaceable wear ring. The impellers shall be secured to the pump shaft with tapered conical sleeves pressed into the taper bore of impeller or impeller secured through chrome plated stainless steel hexagonal sleeves. Suction casing shall be between pump and motor with suction strainer as protection of pump against coarse impurities of the liquid handled.

Dimensions

The maximum outside dimension of the pump shall be compatible with the size of well casing, for the discharges and heads given in the Bill of Quantities.

Column Pipe

The column pipe shall be flanged ERW steel pipes confirming to ASTM designation A- 53 with a minimum thickness of 4mm and shall be painted with corrosion resistance paint of suitable thickness. Flanges thickness of 20mm shall have grooves for cable passage. Each column pipe shall be complete with gaskets, bolts/studs, washers and nuts. All nuts, bolts, and washers shall be made of minimum A2 grade stainless steel. The column pipe shall be supplied in interchangeable section having an approximate length of 10 feet. The flanges shall be welded perfectly perpendicular to the axis of the pipe. The column pipe shall have following features;

- Dimensional accuracy circularity and plan end cut shall be observed,
- Weld strength of pipe and mechanical properties or raw material shall be tested as per manufacturing standards.
- Pipes shall be NDT tested (Non-destructive - Eddy current)
- Pipes shall be tested for hydrostatic pressure as per manufacturing standard.
- Pipes shall gone through straightening process to remove bendiness.

TOP SET:

Top set shall comprise of Bore covers plate, (covering bore hole completely and securely), installation/suspension clamps, sluice valve, reflex valve, connector and cable jointing material (Cable connection from motor to switching device shall be joint free) pressure gauge and cable ties.

Motor

The submersible motor shall be three phase squirrel cage water filled submersible motor manufactured in compliance with National Electrical Manufacturer Association (NEMA) standards. The submersible motor shall be wet type, water cool rewind-able/repairable stator, three-phase submersible and shall be capable of operating at rated voltage of 400 Volts at 50 Hz, insulation with IP68 protection. The synchronous speed should be 2850-2950 RPM. Motor shall be capable of operating in well water with temperature starting from 40C. Motor shall be designed for continuous operation. The motor must be properly protected against the entry of well water sand etc. by double mechanical seal i.e. one rotating and other stationary and the

seal must be made of Silicon carbide/ Tungsten carbide and must be protected with sand protection guards. All supports shall be high grade cast iron and stator outer side jacket body should be in stainless steel in AISI 304. The excessive pressure due to heating up of the filled water must be compensated by a pressure equalizing rubber diaphragm in the lower part of the motor. The axial thrust of the pump shall be countered by oscillating sliding block type thrust bearing. The thrust bearing of the motor should be able to bear a download thrust force from the water pump and the upward thrust force produced while starting the water pump. Motor shall be capable of minimum of 20 starts in an hour. Motor efficiency shall not be less than 50%.

Submersible Cable & Joint

The submersible cable shall be made up of 99% copper coated with double PVC and shall be adequately flexible and environment friendly. The cable shall have undergone quality tests as per BSS standards. Following tests are mandatory.

- Conductor resistance test
- Insulation resistance test
- Pressure test
- Spark test

The supplier shall provide the manufactures quality test certificate at the time of supply. The motor cable and drop cable shall be jointed together by means of a water resistant cable splicing kit.

Pressure Switch & Pressure Gauge

A pressure switch and a pressure gauge with cock suitable for a range of 0 to 16 bar pressure shall be provided at the delivery pipe at suitable point to the approval of the Engineer.

VALVES AND APPURTENANCES

All valves supplied shall be suitable for use with water temperatures upto 50°C and in climatic and soil conditions encountered in the Project Area. The nominal working pressure shall be 16 bar. All hydrants, valves and appurtenances shall be externally and internally fusion bonded epoxy coated using electrostatic/fluidized bed process with a minimum thickness of 300 microns, holiday-free and non-toxic. Before application of epoxy coating the surface shall be sand blasted to a minimum of SA 2.5 and air blown to ensure good bond. The valves shall be supplied complete with metal reinforced flange gaskets and galvanized steel nuts, bolts and washers. Unless otherwise detailed or specified herein, gate and butterfly valves shall be supplied complete with stainless steel type AISI 304L extension spindles and appurtenances such that the square nut operator is within 500 mm of the top of the chamber cover slab.

All valves shall be tested to the appropriate test pressure at the manufacturer's works, and shall be supported by a test certificate from the manufacturer. Work tests on valves 300mm dia and larger shall be witnessed and certified by an approved independent testing agency at no extra cost to the Employer.

Markings of valves shall include the following:

- Manufacturing Standard
- Manufacturer's Name or Trademark
- Nominal Diameter(S) (N.D) In Mm Pressure Rating in Bars
- An Individual Serial Number Which Relates Directly to The Manufacturer's Test Certificate
- Month and Year of Manufacture.

Position indicators shall be provided on all gate and check valves.

The maximum effort required to operate the valve against the maximum unbalanced head applied at the circumference of the hand wheel or end of the tee-key shall not exceed 15 kNm, where necessary gearing shall be provided.

The Contractor shall supply the original manufacturer's test certificate endorsed by the approved independent testing agency for each valve supplied. The certificate shall relate to the individual number cast on each valve and shall give the date of test.

Before proceeding with any manufacturing, submit Shop Drawings for Engineer's prior written approval. **Gate Valves**

Gate valves shall conform to the provisions of BS 5163 or approved equal and as further specified herein. The valves shall be inside screw, non-rising stem, clockwise closing wedge gate valves suitable for underground use. The direction of opening and closing shall be clearly marked.

The minimum designed working pressure shall be 16 bar. Valve pressure ratings shall equal the class of pipe and shall be designed for the "Closed End Test".

All gate valves shall be designed to provide 100% water tight shut off at all specified pressures.

Valves shall be clock-wise closing using a square nut operator. Valves above 300mm dia shall be gear operated and hand wheels shall be provided where directed by the Engineer.

Air Valves

Air valves shall be designed to

- (a) Discharge air during filling of pipelines
- (b) Admit air during emptying of pipelines
- (c) Discharge air accumulated at high points in pipelines during normal operation.

Double orifice air valves which shall combine both large and small orifices within one valve. The large orifice shall be sealed by a buoyant rigid ball and the chamber housing shall be designed to avoid premature closing of the valve by the air whilst being discharged. The small orifice shall be sealed by a buoyant ball at all pressures above atmospheric, except when air accumulates in the valve chamber.

Air valve bodies shall be flanged, with flanges drilled to PN 16 in accordance with BS 4504. Each valve or valve assembly shall be installed complete with isolation valve whether or not indicated on the Drawings. Valves shall be designed for a water working pressure of not less than 16 bar and shall have floats and all working parts made of stainless steel seat of nitrile rubber with body and cover of ductile iron.

Check Valves

Check valves shall be mounted horizontally and be double flanged.

Check valves shall be swing check valves to BS 5153 PN 16 straight pattern metal seated, flanged BS 4504 PN 16 temperature range of -10°C to 65°C .

The face to face length shall be short.

Provision shall be made for a body tapping on valve as per BS standard.

Flow Meter

Flow meter will be of different sizes ranging from 3” to 8”. Its installation can be in horizontal or vertical. The flow meters should be operating at temperatures up to 50°C and a maximum working pressure of 16 bar. Accuracy should be maintained in both forward and reverse flow. The meter complies with all relevant international quality standards, substantially exceeding ISO4064 BS5728 Class B specifications for forward flow installations in horizontal, vertical and inclined pipelines.

Pressure Gauge

Pressure gauge will be provided vertically on delivery main. Gauges mounted directly on piping should be assembled with reasonable care, always using wrench grip provided on pressure connection to secure it to the threading fitting. Gauges should be free of piping strains when mounted. If mounting surface, us uneven, insert washers under flange of the gauge case to obtain a three-point suspension.

Case should be made of stainless steel and ring should be threaded or crimped. Its window should be of glass or clear plastic or shatter resistant glass. Its connection will be bottom male and lower back male

Its dial Size should be ranging from 3” to 6”. The maximum pressure at which a pressure gauge is continually operated should not exceed 75% of full scale pressure.

Water Chemical Testing

The proposed water supply source to be used for water of domestic needs should be of acceptable quality in accordance with the guidelines of World Health Organization (WHO) which is presently being followed in Pakistan. Table shows the WHO Guidelines for Potable Water Quality.

Table: WHO guidelines for portable water quality

Sr. No	Parameter	W.H.O. Desirable levels	W.H.O Maximum permissible levels
1	Temperature ° C	-	-
2	pH	7.0-8.0	6.5-8.5
3	Odour	Unobjectionable	Unobjectionable
4	Colour	5 Units	50 Units
5	Taste	Unobjectionable	Unobjectionable
6	Turbidity N.T.U.	5 Units	25 Units
7	Total dissolved solids	500	1500
8	Calcium	75	200
9	Magnesium	50	150
10	Total Hardness mg/l as CaCO ₃	100	500
11	Sulphates	200	400
12	Chlorides	200	250
13	Iron	0.1	0.3

