ARAB REPUBLIC OF EGYPT
ASWAN GOVERNORATE

ASWAN WATER AND SANITATION COMPANY
SEWAGE PUMP STATION PROJECT AL-SAIL

Schweizerische Eidgenossenschaft
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EBP
Association with:

ELECTROMECHANICAL SPECIFICATIONS

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MECHANICAL SPECIFICATIONS

CHAPTER 1

WASTEWATER PUMPING UNITS

PART-1 GENERAL

1.1 WORK INCLUDED

A. This section includes the manufacture. delivery, installation, testing, commissioning, guarantee and maintenance of pumps complete with accessories and spares as specified in the following clauses.

B. Provide all labor, materials, equipment and incidentals necessary to furnish, install and test the miscellaneous pumping units as specified herein and as shown on the Drawings .

C. The following types of pumps shall be specified hereinafter and the units shall be complete with electric motors, starters, and automatic controls where specified or shown, floor plates and all other necessary appurtenances

1. Centrifugal Pumps.
2. Submersible Centrifugal Pumps.

D. Pumps shall be designed for the specified performance and shall operate without overheating, excessive vibration, or strain.

E. All parts shall be so designed and proportioned as to have liberal strength, stability, and stiffness and to be especially adapted for the work to be done.

1.2 REFERENCES AND STANDARDS

- The following standards are referred to.
- ISO 2858 End-suction centrifugal pumps (rating 16 bar) - Designation, nominal duty point and dimensions
- ISO 3069 End-suction centrifugal pumps Dimension of cavities for mechanical seals and for soft packing
- DIN 19704 Hydraulic steel structures. Criteria for design and calculation.
- DIN 19705 - Recommendation for the design construction and erection of hydraulic steel structure equipment.
- DIN 4114 Steel construction.

1.3 SUBMITTALS

A. Literature, pump characteristic curves showing head-capacity, horsepower, efficiency and required NPSH, detail drawings including materials, construction and parts list to indicate full conformance with the detail specifications and to show installation details shall be submitted to the Engineer.

B. Inspection and testing of raw materials used in the manufacture of the equipment: the Contractor shall supply certificates of mechanical tests and chemical analysis.

C. Inspection and testing of standard products: the Contractor shall supply certificates of routine tests.

D. Inspection and testing of raw materials used in the manufacture of the equipment: the Contractor shall supply certificates of mechanical tests and chemical analysis.

E. Inspection and testing of standard products: the Contractor shall supply certificates of routine tests.

1.4 IDENTIFICATION

A. Brass or stainless steel nameplates giving the name of the manufacturer, the rated capacity, head, speed, model and serial number and other pertinent data shall be attached to each pump.

1.5 SPARE PARTS AND TOOLS

A. The tenderer shall supply spare parts and tools for all the machinery and equipment offered which he recommends as being necessary for maintenance purposes as specified.

PART-2 PRODUCTS :

2.1 CENTRIFUGAL PUMPS

2.1.1 General

A. Sewage pumps shall he Vertical assembly centrifugal pumps directly connected to the motor with a flexible coupling and complete with seals and bearings. Each pump and motor unit shall be mounted on a steel or case iron common plate, Suction and discharge of the pump shall be flanged end.

B. The number of standby pumps shall be 100% of duty pumps as per Egyptian code.

C. The pumps shall be designed and manufactured in accordance with ISO 2858.

D. Pumps of equal head-capacity characteristic shall have identical features of construction and parts shall be interchangeable. Unless otherwise specified the pump casing design pressure shall be their shut-off pressure plus 10.0 m, and the pump casing shall be hydrostatically tested to 150 percent of their casing design pressure. Minimum time of hydrostatic tests shall be 3 minutes.

E. Pump impeller shall pass solids up to 100 mm.

F. Pump casing shall be equipped with leaning manhole of ample size.

G. All essential and desirable indicator lubrication devices and other accessories for the pumping units shall be provided.

H. Pump and motor rotational speed shall be selected as the minimum possible speed. Speed of rotation shall be 1500 rpm, 1000 rpm or 750 rpm as per supplier selection of best efficiency and long life time

I. Pump motor shall be squirrel cage type, 380 V, 50 Hz. Motor insulation shall be class F, temperature rise shall be class B. Motor rating shall be 10% higher than the power required

at the operating range.

J. Motor shall be fitted with bearing temperature protection.

K.

2.1.2 Construction and Materials

A. Casing

1. The casing shall be of cast iron conforming to approved standard, with smooth waterway and fitted with wearing rings.
2. The wearing rings shall be of bronze casting conforming to approved standard.
3. Casing shall be constructed so that the back casing and rotating parts shall be removed without disturbing the volute case and the suction and discharge piping.

B. Impeller

1. The impeller shall be enclosed, accurately machined and statically and dynamically balanced.
2. The impeller shall be made of either of the following materials.

- Cast iron conforming to approved standard.
- Stainless steel, type 316.

C. Shaft

1. The pump shaft shall be of stainless steel conforming to approved standard, precision ground and provided with renewable bronze or stainless steel sleeve where it passes through the stuffing box and is in contact with water.
2. The shaft shall be rigidly supported by at two (2) sets heavy-duty antifriction ball bearings conforming to JISB 1521 or B 1522.
3. Lubrication of bearings shall be by oil or grease and in case of oil lubrication, appropriate provisions for oil level checking and an oil drain shall be provided.

D. Stuffing Box

1. The stuffing box shall be of such design and size as to ensure tight packing without excessive wear or friction on the shaft sleeve.
2. Dimensions of stuffing box shall conform to ISO 3069.
3. The stuffing box shall be provided with at least five (5) square packing rings with a lantern ring.
4. An easily removable gland shall be provided for the stuffing box.
5. The gland shaft be of stainless steel or cast iron.

E. Shaft Coupling

1. The shaft coupling between pump and motor shall be the flexible type and shall conform to approved standard. Couplings, shall be provided with guards

2.1.3 Accessories and Spare Parts

A. Accessories

For each pump, all essential and desirable accessories for installation and operation shall be furnished and. installed which shall include but not be limited to the following:

1. One (1) Set of Common base plates
2. One (1) Set of anchor bolts and nuts
3. One (1) Set of couplings with guard
4. One (1) Set of casing drain valves
5. Two (2) Sets of pressure gauges with cocks for pump suction and discharge

B. Spare Parts

The following spare parts shall be furnished for each pump.

1. One (1) Complete set of sleeves
2. One (1) Complete set of bearings
3. Two (2) Complete sets of gland packing
4. One (1) Complete set of oil seals
5. One (1) Complete set of gaskets

2.2 SUBMERSIBLE CENTRIFUGAL PUMPS

2.2.1 General

A. The sewage pump shall be of the vertical single stage, non-clogging impeller type or semi-open impeller type, directly connected to the motor with shaft seal and bearings.

B. The number of standby pumps shall be 100% of duty pumps as per Egyptian code.

C. The number of standby pumps shall be 100% of duty pumps as per Egyptian code.

D. The pumps shall be designed and manufactured in accordance with ISO 2858.

E. Pumps of equal head-capacity characteristic shall have identical features of construction and parts shall be inter changeable. Unless otherwise specified the pump casing design pressure shall be their shut-off pressure plus 10.0 m, and the pump casing shall be hydrostatically tested to 150 percent of their casing design pressure. Minimum time of hydrostatic tests shall be 3 minutes.

F. Each motor shall be fitted with the thermal protector to protect the motor from damages, particularly for the large sewage pump and water leakage detector built in the pump to prevent the motor from burning, when water has soaked into the motor or the forced cooling system (by circulating wastewater in the double casing provided with the motor) provided in the pump to cool down the motor. The sealing between pump and motor shall be through double mechanical seal with oil filled chamber.

G. Sewage pumps installed in wet well shall be externally cooled. Sewage pumps installed in dry well shall have cooling jacket using the pumped fluid.

H. Submersible sewage pump shaft sealing shall be through double mechanical seals in oil filled chamber. The mechanical seals shall be independent of the direction of rotation and made of Tungsten carbide.

I. Pump impeller shall pass solids up to 100 mm.

J. Pump casing shall be equipped with leaning manhole of ample size.

K. All essential and desirable indicator lubrication devices and other accessories for the pumping units shall be provided.

L. Pump and motor rotational speed shall be selected as the minimum possible speed. Speed of rotation shall be 1500 rpm, 1000 rpm or 750 rpm as per supplier selection of best efficiency and long life time, or as specified in the bill of quantities.

M. Pump motor shall be squirrel cage type, 380 V, 50 Hz. Motor insulation shall be class F, temperature rise shall be class B. Motor rating shall be 10% higher than the power required at the operating range.

N. Motor shall be fitted with bearing temperature protection.

2.2.2 Construction and Materials

A. When pumps are installed in wet well, the pump shall be fitted with the cable and detachable system with guide pipe and chain to take out easily the pump for maintenance works. The pump shall be raised without need to dismantle discharge elbow. The elbow with pump coupling shall be fixed on sump floor.

B. When pumps are installed in wet well, pump guide rails and lifting chain shall be made of stainless steel.

C. Materials of the pump casing impeller and shaft shall be cast iron and stainless respectively or equivalent.

O. Each motor shall be fitted with the thermal protector to protect the motor from damages.

P. Water leakage detector built in the pump to prevent the motor from burning, when water has soaked into the motor or the forced cooling system (by circulating wastewater in the double casing provided with the motor) provided in the pump to cool down the motor.

Q. The sealing between pump and motor shall be through double mechanical seal with oil filled chamber, independent of the direction of rotation.

2.2.3 Pump Operation

A. Operation of each pump shall be automatically or manually controlled through level switches with associated relays and switches which shall start each pump successively if the water continues to rise above predetermined levels in the wet well and shut them all off when the water has been lowered to the predetermined level.

B. In normal operation, one pump usually starts at pump 1 start level, pump 2 starts at pump 2

start level. Pumps shall be stopped at the stop level of each pump.

C. An automatic alternating pump starting system shall be provided.

2.2.4 Accessories and Spare Parts

A. Accessories

1. For each pump all essential and desirable accessories for installation and operation shall be furnished and installed which shall include but not be limited to the following:
   a) One (1) Guide pipe
   b) One (1) Chain (Stainless steel)
   c) One (1) Detachable unit
   d) One (1) Cable
   e) One (1) Foundation bolts/nuts

B. Spare Parts

A. The following spare parts shall be furnished for each pump.

a) One (1) Complete set of bearings.
b) One (1) Complete set of mechanical seals.
c) One (1) Complete set of oil seal.
d) One (1) Complete set of gaskets.

2.3 MOTORS

2.3.1 General

A. The motors for the pumps except for horizontal peripheral pumps shall have sufficient rating to operate the pump at any point on its characteristic curve without overloading, and in addition it shall have a service factor of at least 1.15 at the rated operation point.

B. The motors for the horizontal peripheral pump shall have sufficient rating to operate the pump at any point in its characteristic curve without overloading and in addition it shall have a service factor of at least 1.10 at the point of maximum flow.

C. Unless otherwise specified motors, which are rated at 30 kW and smaller shall be the totally enclosed fan cooled type and motors of output 37 kW and larger shall be the open drip-proof type.

D. Motor power source shall be 380 V (or higher voltage as specified) ,50 Hz, IP 67 for vertical pumps in dry locations and IP 68 for submersible pumps. If submersible pumps are employed in dry pits, the motor cooling shall be via cooling jacket either by sewage water or special fluid.

2.3.2 Spare Parts and Tools

A. All spare parts for each pump,specified hereinafter shall he furnished.

B. For each pump one (1) set of special tools for maintenance be supplied in painted steel cases and identified on the outside With an itemized list of contents.

C. One set of mechanical seal shall be provided for each pump.

D. One impeller shall be provided as spare.

E. One set of bearings shall be provided as spare

PART-3 EXECUTION:

3.1 SHOP AND FIELD PAINTING

A. The pumps couplings motor and bedplates shall receive shop and field coats. All interior ferrous and non- machined surfaces of casings shall be shop painted with tar epoxy paint, using Paint system specified in relevant sections of these specifications.

B. Painting shall conform to the requirements as specified in the relevant sections unless otherwise specified .

3.2 TESTS

3.2.1 Factory Performance Tests

A. Unless otherwise specified, all pumps shall be tested at the manufacturer's plant to demonstrate complete compliance with these specifications.

B. The tests shall be in full compliance with the approved standards.

C. Six (6) copies of test data shall be submitted for the Engineer's approval.

3.2.2 Field Tests

A. As soon as convenient after the equipment is installed each pump shall be field tested to determine that the units have been properly installed to verify factory tests, and to demonstrate that the complete units will operate continuously without over heating and that the drives are not overloaded.

B. The tests on each unit shall be for a period of four (4) continuous hours.

C. During the operation the total head shall be as near the specified design head as conditions at the site will permit.

D. If required readings of all essential data shall be taken and recorded at one minute intervals.

E. All instruments required for the readings shall be furnished by the Contractor at no additional cost.

Chapter 2

PROCESS PIPING

PART 1: GENERAL

1.1 GENERAL

1.1.1 Scope of work

- All pipes, fittings and appurtenances shall be furnished by the Contractor, In addition the Contractor shall furnish all labor, materials, equipment and incidentals required to install the piping, fittings and appurtenances as shown on the drawings. The completed installation shall be fully functional as shown on the drawings. The fittings where shown are as a convenience to the Contractor. It may be necessary to supply and install additional fittings other than those shown on the drawings or to install fittings in different locations. The Contractor shall refer to the Special Technical Specifications fora description of the scope of work.
- Also included under this Section is the supply and installation of certain miscellaneous items and appurtenances as hereinafter specified. Work to be done shall include handling, laying, installing, jointing, welding, testing, chlorinating and all other work necessary to produce a completes facility. The Contractor shall furnish and install couplings, fittings, gaskets, insulation, flanges, bolts, nuts, wall sleeves, wall pipes, hardnesses and all other materials necessary to properly install the work shown on the drawings and as specified.
- Certain piping systems are shown diagrammatically as an indication of the work to be installed. The Contractor shall coordinate the work such that all works may be installed in the most direct and workman like manner, and so that interference between piping, ducts, equipment, architectural and structural features and appurtenances and other work will be avoided.
- The work of installing pipe in earth excavations, earth fills and earth trenches.

1.1.2 Shop drawings

A. The Contractor shall submit detailed working and shop drawings and schedules of all pipe, fittings and appurtenances. Shop drawings shall include but not be limited to the following:

1. List and schedules of material, linings and coatings.
2. Schedules of pipe lengths and thicknesses.
3. Calculations, sketches and special details.
4. Details of proposed joints, hardnesses and installation details.
5. Names of suppliers and identification of materials and equipment to be supplied.
6. Dates of delivery of materials to jobsite
7. Special enclosures.

B. For reinforced concrete pipes (if selected by contractor), the Contractor shall furnish all information related to placement of steel reinforcement, and a complete set of design calculations. Installation manuals shall also be furnished when requested.

C. Shop drawings shall show the locations of unions, bolted flanged connections or other appurtenances to permit ready dismantling of piping systems.

D. The work of this section shall be completely coordinated with the work of other sections. The Contractor shall verify at the site, both the dimensions and work of other sections, which adjoin his materials. Field measurements shall be taken at the site and incorporated in the shop drawings, with specific notes.

E. The Contractor shall furnish a mill certified report, in triplicate, of the tests for each material to be utilized in the work. The certifications shall contain the results of chemical and physical test required by these specifications for the materials.

F. For both shop and field welds of steel pipe, the following information shall be submitted.

   A. Method of welding - automatic or manual.

   B. Type of welding rods

   C. Method of preparing edges

   D. Welding procedure

   E. Cleaning of welds

G. The Contractor shall submit samples of materials to be supplied under this section upon written direction of the Engineer.

H. The Contractor shall submit, for approval, exact details of various joints that are proposed for use on this project which originate in different countries and which differ, form these specifications. In the event the Engineer approves these different joints, the Contractor shall assume all responsibilities regarding the coordinating and providing of proper joints and connections.

1.1.3 Pipes and fittings

A. General

1. Each pipe, fitting and casting shall bear clear and durable markings showing the nominal diameter, class or schedule, type, year of manufacture and the manufacturer's name or trademark. Marking on pipe lengths shall always be at the same end. Painting of data will be acceptable for all pipe material except ductile iron and cast iron pipe. Each pipe and fitting of ductile iron and cast iron material shall bear cast on markings showing the data described above.

2. Pipes and fittings shall be compatible and have equal or higher-pressure ratings as specified. Pipes, fittings and appurtenances shall be installed in full conformance with the manufacturer's recommendations.

3. Bedding, hanger details, supports and wall and floor penetrations shall be as shown on the drawings, or specified hereinafter.

4. When cutting of pipe is required, the cutting shall be done by machine in a heat and workmanlike manner without damage to the pipe, coating or lining. Cut ends shall be smooth and at right angles to the axis of the pipe. Pipe ends to be used with rubber joints shall be beveled and filed or ground smoothly to conform to the manufactured spigot end.

5. The Contractor shall furnish and install transition pieces at all locations when one type of pipe joins a second.

B. Handling

1. Care shall be taken during loading, transporting, and unloading to prevent injury to the pipes, fittings, or coatings. Under no circumstances shall pipe or fittings be dropped or rolled against one another. All pipes or fittings shall be examined and no piece shall be installed which is found to be defective. Any damage to the pipe coatings shall be repaired as directed by the Engineer.

2. If any defective pipe or fitting is discovered after it has been installed, it shall be removed and replaced with a sound pipe in a satisfactory manner by the Contractor, at his own expense. All pipe and fittings shall be thoroughly cleaned before installation.

3. Special handling of pipes and fittings shall be in accordance with the manufacturer's instructions.

4. All pipes shall be bundled or packaged in such a manner as to provide adequate protection for the ends, threaded or plain, during transportation from manufacturer to the Contractors storage. All special provisions for ocean shipment shall be provided.

C. Inspection

1. The quality of all materials, the process of manufacturer, and the finished piping shall be subject to inspection and approval by the Engineer by an independent testing laboratory selected by the Employer, or by other representatives of the Employer.

2. Such inspection may be made at the place or manufacture or at the site after delivery or at both places, and the pipe shall be subject to rejection at any time on account of failure to meet any of the specification requirements even though sample pipes may have been accepted as satisfactory .

3. Inspections, at point of manufacture. will require the Contractor’s and manufacturer cooperation. The cost of foundry or factory inspection of piping approved for these works will be at the Employer's expense

4. When any routine chemical analysis fails to meet the requirements of these specification or when any specified test fails to meet the requirements, all pipe in the same sampling period shall be rejected, except that any pipe that is subsequently retested and is judged acceptable; may be accepted.

5. All pipes and appurtenances will be inspected by the Engineer upon delivery to the site and those pieces not conforming to the requirements of this specification, will be rejected and must be immediately removed from the site by the Contractor. The Contractor shall furnish all labor necessary to assist in inspecting the material.

6. On completing the installation, the inside of the pipe shall be carefully cleaned of tools, scrap, dirt and debris. The Engineer will make a full and complete inspection of all lines before acceptance and the Contractor shall fully flush out the lines with water and air prior to inspection.

D. Flanged joints

1. Flanged joints shall be furnished complete with gaskets, bolts and nuts.
2. Gaskets shall be cut to the proper size so that no part protrudes. Prior to application of gaskets, the face of the flanges shall be thoroughly cleaned.
3. All gaskets supplied with each flanged fitting shall be styrene butadiene rubber (SBR). Thickness of gasket shall be 3 mm or equivalent.
4. Flanged assembly bolts shall be standard hexagon head machine bolts with hexagon nuts. Threads shall conform to ISO 68, "ISO General Purpose Screw Threads. Material for bolts and nuts shall be steel conforming to, ASTM, DIN or BS or other internationally accepted standards, and shall have a minimum yield strength of not less than 2,300 kg/cm2. Steel bolts and nuts shall be galvanized. Bolts and nuts for intermittent or continuous underwater pipe work shall be type 304 stainless steel. Bolts and nuts for stainless steel flanges shall be stainless steel and type of stainless steel shall be the same as the flanges.
5. Bolts in flanged joints shall be tightened alternately on opposite ends of joints diameters, in rotation around the flange and evenly.
6. The bolts shall not protrude more than 3 mm beyond the nuts. Should the bolts protrude more than 3 mm. the bolt ends shall be machined, cut refinished.
7. Mating dimensions if flanges, nominal diameter 100 mm to 2,000 mm. shall conform to ISO 2084, "Pipeline Flanges for General Use Metric Series - Mating Dimensions". NP 10 as shown on the following FLANGE SCHEDULE or according to other internationally accepted standards. Mating dimensions and thicknesses of flange, nominal diameter 80 mm and smaller, shall conform to ISO, ANSI, DIN, or BS, or other internationally accepted standard, and the working pressure of the flange shall be 10.0 kg/cm2.

1.1.4 Schedule

A. The TECHNICAL SPECIFICATIONS AND / OR DRAWINGS (as applicable) contain a piping schedule which includes the service and location, nominal size, pipeline material, lining and coatings, and type of joints for the major piping systems. The range of sizes is shown on the schedules for piping 100 mm in size and larger and for piping systems with smaller piping are noted without sizes. Reference to the drawings is required for these smaller sizes.

B. The completeness of this schedule is not guaranteed and the omission of piping in the schedule needed to complete the work shall not relieve the Contractor from his responsibility for furnishing and installation of the work complete.

1.1.5 Routing of Pipelines

A. It the responsibility of the Contractor to route all piping shall be routed in such a way as not to interfere with other piping, equipment. Instrumentation. and electrical work of structures Pipeline routing shall he in accordance with the guidelines presented in the Drawings (as applicable) Minor changes due to differences in equipment. size or configurations will he permitted provided that such changes do not interfere with other work Any major deviations from the layouts shown on the Drawings will be considered substitutions and shall require approval as such. All piping layouts shall be subject to approval by the Engineer prior to installation

B. All exposed piping shall be located against walls, under ceilings, or in floor trenches. If floor trenches are used, gratings, shall he installed to cover the trench Piping shall not be routed under floor slabs unless specifically shown as such on the Drawings (as applicable) In no case shall piping be located so as to interfere in any way with traffic or access to equipment. Minimum headroom shall be 2 meters unless specifically shown otherwise on the Drawings (as applicable),

C. All piping running below concrete structures shall be encased in concrete even if not specifically shown on the Drawings (as applicable).

D. Unless specifically shown on the Drawings (as applicable) or approved by the Engineer, no wall penetrations shall be made underwater.

2. PRODUCTS

2.1 GENERAL

A. All materials furnished under this Contract shall be new and guaranteed against defects in materials, design and workmanship. It shall be the Contractor's responsibility to determine the conditions and service under which the materials will operate, and to warrant that operations under those conditions shall be successful. All parts of the materials shall be amply proportioned for all stresses that may occur during fabrication, erection, and intermittent and continuous operation.

B. All materials shall be designed, fabricated, and assembled in accordance with the best modern engineering and shop practice. Individual parts shall be manufactured to standard size and gauges so that replacement parts, furnished at any time, can be installed in the field. Like parts of duplicate units shall be interchangeable. Materials shall not have been in service at any time prior to delivery, except as required by tests. Materials shall be suitable for service conditions.

C. Materials to be used for manufacturing and installation of the equipment herein specified shall be selected form the best available for the purpose of use considering strength, ductility, durability, and on the basis of the best current engineering practice. Materials shall be (1) new, unused and of first quality, (2) free from defects and (3) suitable for the application and not overstressed mechanically or electrically.

2.2 PIPING

2.2.1 Ductile Cast Iron Pipes (D.C.I)

A. General

1. All piping shall be designed for a minimum working pressure of 6.0 kg/cm2 unless noted otherwise.
2. Ductile iron pipes and fittings, joint materials and accessories shall be manufactured in accordance with all provisions specified hereinafter and to a single standard. Outside diameters of pipes and fittings in all sizes shall conform to Egyptian Ministerial Decree No. 164 (2015) unless the products have been prefabricated at the supplier's country. All dimensions of joints of pipes and fittings shall also be in accordance with Egyptian standard Ministry Decree No. 164 (2015).

B. Pipes

1. Ductile iron pipes shall exhibit at least the following physical characteristics :
   a. Minimum Tensile strength 42 kg/mm^2
   b. Minimum Elongation
      - 1,000 mm and smaller in diameter 10 %
      - 1,000 mm and larger in diameter 7 %
2. The pipes shall conform to Egyptian Ministerial Decree No. 164 (2015), and their full length shall not exceed six (6) meters. The pipe shall be manufactured by the centrifugal casting method.

C. Fittings

1. Ductile iron fittings shall exhibit at least the following physical characteristics:
   a. Minimum Tensile Strength 4.0 kg/mm.
      392 N/mm.
   b. Minimum Elongation 5%
2. Fittings shall have dimensions conforming to Egyptian standard Ministry Decree No.164 (2015) and later decrees.
3. If fittings and special castings, specified herein or shown on the Drawings (as applicable), are not covered in these specifications, the Contractor shall submit shop drawings and / or manufacturer's specifications to the Engineer for approval prior to casting.

D. Coating And Linings

1. Coatings
   a. All non-exposed pipes and fittings buried in the ground shall have a bituminous coating of either coal tar or asphaltic base with a minimum thickness of 0.1 mm. The finished coating shall be continuous, smooth, neither brittle when cold nor sticky when hot, and strongly adherent to the pipe and fittings.
   b. All pipes and fittings exposed to ground in the finished work, or to be in an intermittent or continuous submerged condition, shall be painted on the exterior in accordance to the ministerial Decree No. 164 (2015) and later decrees unless otherwise noted.

2. Linings

   a. All pipes shall have a cement mortar lining conforming to Egyptian standard Ministry Decree No. 164 (2015) unless the products have been prefabricated.

   b. Defective or damaged areas of lining shall be patched with stiff mortar or with epoxy resin filler or paste by cutting out the defective or damaged lining to the metal so that edges of the lining not removed are perpendicular or slightly undercut. Materials of epoxy resin filler or paste shall be approved by the Engineer before being applied.

   c. All fittings shall be lined with non-toxic type coal tar epoxy and total dry film thickness of the lining shall be not less than 300 microns. The lining material shall be certified by the recognized public health authorities of linings in potable water service.

3. Joints

   - General

     a. Pipes in size 250 mm and smaller shall be furnished with push-on joints or flanges. Pipes in sizes 300 mm and larger shall be furnished with push-on joints, mechanical joints or flanges. Type of joints shall be as specified on the Drawings or Piping Schedule of the Special Technical Specifications.

     b. All joints shall be designed to have the same characteristics and strength as the connecting pipe.

   - Mechanical Joints,

     a. Mechanical joints shall conform to Egyptian standard Ministry decree 164 (2015) or manufacturers standards approved by the Engineer.

     b. All ductile iron pipes and fittings of the mechanical joint type shall be provided complete jointing materials unless otherwise specified.

     c. Gasket of the mechanical joint shall be styrene butadiene rubber (SBR) conforming to Egyptian standard Ministry Decree No. 164 (2015) and later decrees or manufacturer's standard approved by the Engineer.

     d. Reclaimed rubber shall not be used. Gland, bolts and nuts shall be of spheroidal graphite iron castings conforming Egyptian standard Ministry Decree No. 164(2015) or manufacturers standard approved by the Engineer.

   - Push - on Joints

     a. Push - on joints shall conform to Egyptian standard Ministry Decree No. 164 (2015) and later decrees or manufacturers standard approved by the Engineer.

     b. The plain end of the pipe shall have slight taper to case its sliding-fit with the gasket when the joint is made. Field cut pipe shall be ground to have a taper the same as the factory manufactured spigot ends.

     c. Push- on joint pipe shall be furnished complete with gaskets and lubricants recommended by the manufacturer.

d. Gaskets shall be of the same material specified for mechanical joints of the previous subsection.

e. Fittings for push-on joint pipe shall be mechanical joint fittings unless otherwise specified.

- Flanged Joints

a. All flanges shall be integrally casted with the pipe of fittings and shall have raised faces on the gasket surface.

2.2.2 Steel Pipes

A. General

1. All piping shall be designed for a minimum working pressure of 6.0 kg/cm2, unless noted otherwise and conform to Egyptian standard Ministry Decree No. 164 (2015) and later decrees unless the products have been prefabricated.

B. Pipes

1. Materials and Fabrication

a. Steel pipe shall be fabricated from steel sheets or plates and shall be arc welded or electric-resistance welded, shop fabricated, tested and cleaned.

b. Steel sheets or plates shall have a minimum yield point not less than 2.300 kg/cm2 (226 n/mm2) and shall conform to Egyptian standard Ministry Decree No. 164 (2015) and later decrees.

c. Fabrication of steel pipe shall be in accordance with Egyptian standard Ministry Decree No. 164 (2015) and later decrees. The weld shall be of reasonably uniform width and height for the entire length of the pipe and shall be made by automatic means except that, with approval of the Engineer, manual welding by a qualified procedure and welder may be used.

d. All longitudinal seams or spiral seams and shop girth seams of pipe shall be butt-welded. The maximum allowable number of shop seams shall be one longitudinal seam and three girth seams per length of pipe.

The longitudinal seams shall be staggered on opposite sides for adjacent section. No reinforcing ring, plate or saddle shall be provided on the exterior or interior of pipe .The length of pipe shall be six (6) meters or less unless otherwise specified .

2. Pipe Dimensions

a. The nominal pipe diameters shown on the drawings (as applicable) shall be of the following outside diameters and wall thickness before lining and coating.

Exterior Diameter and Wall Thickness for Steel Pipes

Nominal Diameter (mm)	Exterior Diameter (mm)	Min. Wall Thickness (mm)
1 5	21.7	28

20	27,2	2.8
25	34.0	3.2
32	42.7	3.5
40	48.6	3,5
50	60.5	3,8
65	76.3	4.2
80	89.1	4.2
100	114.3	4.5
125	139.8	4.5
150	165.2	5.0
200	216.3	5.8
250	267.4	6.6
300	318.5	6.9
350	355.6	6.0
400	406.4	6.0
450	457.2	6.0
500	508.0	6.0
600	609.6	6.0
700	711.2	6.0
800	812.8	7.1
900	914.4	7.9
1,000	1,016.0	8.
1,100	1,117.6	10.3
1,200	1,219.2	11.1
1,350	1,317.6	11.9
1,500	1,524.0	12.7
1,600	1,680.0	14.0
1,800	1,628.0	16.0

3. Fittings

   a. Fittings shall be shop fabricated and shall be designed to have the same strength as piping. Reinforcing rings or saddles shall be provided where required in accordance with Egyptian standard Ministry Decree No. 164 (2015) and later decrees, and to meet the operating conditions of 6 kg/cm2.

   b. Bends having a deflection angle of 22.5 degrees and smaller shall be two-piece bends. Bends having a deflection angle of over 45 degrees shall be four-piece bends.

4. Coatings and Linings

a. Exterior Protection

- All pipes and fittings, which will be exposed to view in the finished work, or be intermittently or continuously underwater, shall be painted in accordance with Egyptian Ministry Decree 164 (2015) and later decrees.
- The outside of piping , laid below ground level. Shall have coal tar enamel and bonded double asbestos felt warp . The primer and coal tar enamel shall be as follows
- The construction of exterior protection described ,above shall be as follows
  - Primer. Type B specified above
  - Coal tar enamel. Type 1 specified above, dry film thickness 2.4 mm ± 0.8 mm;
  - Bonded asbestos felt.
  - Coal tar enamel. Type 1 same as the above, dry film thickness 0.8 mm minimum;
  - Bonded asbestos felt, and
  - One coat of water-resistant whitewash.

b. Linings

- Unless specifically noted otherwise, all steel pipe and fitting shall be epoxy or coal tar epoxy lined on the inside in accordance with Egyptian Ministry Decree No. 164 (2015) and later decrees.
- The lining systems such as epoxy or coal tar epoxy shall be shop applied. They shall consist of the following:

  i. <u>Epoxy System</u>
  - One (1) coat of a liquid two-part chemically cured rust inhibitive epoxy primer
  - One (1) or more coats of a liquid two-part epoxy finish coat, which contains no coal tar.

  ii. <u>Coal Tar Epoxy System</u>
  - One (1) coat of a liquid two-part chemically cured rust inhibitive epoxy primer.
  - Two (2) or more coats of a liquid two-part coal tar epoxy finish coat.

- Primer and finish coat (s) shall be from the same manufacturer.
- The epoxy lining system may alternatively consist of two or more coats of the same epoxy coating without the use of a separate primer. This alternative system shall conform to the requirements of Egyptian standard Ministry Decree No. 164 (2015) and later decrees, and the first coat of this alternative system shall be considered as the primer.

- The total dry film thickness of both coating systems shall not be less than 400 microns nor more than 600 microns.

c. Coatings and Linings at Pipe Ends

- Beveled Ends
  - At beveled ends of pipe and fittings 700mm and larger in diameter, both shop lining and coating shall have a cutback of 15 centimeters to facilitate field welding.
  - At beveled ends of pipe and fittings 600 mm and smaller in diameter, only the coating shall have a cutback of 15 centimeters, and lining shall be extended to the pipe ends to facilitate field welding.
  - All interior and exterior surfaces left as cutback at beveled ends shall be given one (1) shop coat specified in the previous sections of (d).1) Exterior Protections and (d).2) Linings.
  - After field welding, the interior surface left as cutback shall be lined with epoxy system or coal tar epoxy system as specified in the previous section (e).2) Linings and the exterior surface left as cutback shall have a heat shrinkable corrosion protection sleeve which will be specified hereinafter.
- Plain-Ends and Shouldered-Ends
  - At all plain-ends and shouldered-ends below ground specially prepared for sleeve couplings and other flexible or expansion joints, only the coating, except primer, shall have cutback of required length for replacing the coupling or joint. The exterior area which may contact with handling liquid shall have the same coating as the pipe lining specified after removing the said primer completely. After setting coupling or joints, Shall be finished with petrolatum corrosion protective tape, which will be specified hereinafter. the lining shall be extended to the pipe ends.
  - At all plain-ends and shouldered-ends above around specially prepared for couplings and joints the exlerior area which may contact with the handling liquid shall have the same coating as this pipeline specified after removing shop applies primer complelely Atter setting couplings and joints, the remaining area and the exterior of coupling or joints shall be painted in accordance with the TECHNICAL. SPECIFICATIONS unless otherwise noted. The lining shall be extended to the pipe ends
- Flanged Ends
  - At all flanged ends, no cutback of lining and coating shall be provided. The entire surface of the flange shall be painted with the epoxy system.

2.2.3 Galvanized Steel Pipe

A. General

1. All piping shall be designed for a minimum working pressure of 6.0 kg/cm^2, unless noted otherwise and conform to Egyptian standard Ministry Decree No. 164 (2015) and later decrees unless the products have been prefabricated.
2. Galvanized coating on the inside and outside of the pipe with zinc shall conform to Egyptian standard Ministry Decree No. 164 (2015) and later decrees.
3. Thickness of galvanized coating shall be not less than 550 g/m.
4. Field cutting with flame and field welding galvanized steel pipe will not be permitted.

B. Joints

1. General
    a. Piping shall be furnished with standard flange, welded or threaded joints as required by the drawings or specifications.
    b. All joints shall be designated to have the same characteristics and strength as the connecting pipe.
    c. Pipe and fittings for use with sleeve coupling, transition couplings, or expansion joints shall have plain ends.
2. Flanged Joints
    a. Flanges shall be made as seamless forging or cut and fabricated form steel plate. Flanges shall be designed for the design maximum working pressure of 10.0 kg/cm^2.
    b. Flanges shall be raised face flange which shall be made as seamless forging or cut and fabricated from steel plate, and shall be attached to pipe or fittings by means of single butt-weld as shown on the drawings. Steel plate flanges having either a raised or flat face may be allowed to be used for pipes or fittings of 300 mm and smaller in diameter. Steel plate flanges shall be attached to pipes or fittings by means of two (2) filler joints of the size shown on the drawings (as applicable).
3. Welded Joints
    a. Welded joints shall conform to the requirements of Egyptian standard Ministry Decree No. 164 (2015) and later decrees and shall have beveled pipe ends.
    b. Unless otherwise specified, field-welded joints shall be butt-welded joints.
    c. Ends for field welding pipes in sizes 600 mm and under shall be beveled to permit "Single-welded butt joints" from the outside of the pipe.
    d. Ends for field welding pipes in sizes 700 mm and over with a wall thickness of 15 mm and thinner shall be beveled to permit "single-welded butt-joints" from the inside of the pipe.
    e. Ends for field welding pipes in sizes 700 mm and over with wall thickness of 16 mm and thicker shall be beveled to permit "double welded butt joints" from both sides, outside and inside of the pipe.
4. Screw Joints

- Screw joints shall conform to ISO 7/1. Joints shall be made with an approved graphite compound or with polytehatlltoroethylene tape applied to the male threads only.

2.2.4 Flexible Joints and Couplings

A. General

All flexible joints and couplings shall be designed for a minimum working pressure of 6.0 kg/cm2 unless otherwise specified.

B. Mechanical Flexible Joints

1. General

Mechanical flexible joints shall be designed to withstand any forces or any combination of forces due to expansion and contraction, shear deflection, distortion and other forces acting on the pipeline.

2. Design Requirements

Mechanical flexible joints shall be designed and manufactured to meet the operating conditions and design requirements, as enumerated and tabulated below:

a. Two (2) meters depth of earth cover, the unit weight of which is 2.0 ton. m3, plus a 20 ton truck loading.

b. Minimum shear deflection of 100 mm.

c. Other requirements as shown below.

Nominal Diameter (mm)	Max. Laying Length (mm)	Max. Allowable Expansion (mm)	Max. Allowable Contraction (mm)
300 to 400	1,600	230	80
450	1,600	240	80
500 & 600	1,700	270	80
700	1,800	270	90
800 & 900	1,800	310	110
1.00	1,900	300	130
1.100	1,900	300	140
1.200	1,900	300	150
1.350	1,900	300	170
1.500	2,000	350	200
1.600	2,000	350	220
1.800	2,000	370	200

3. Construction and Materials

a. Mechanical flexible joints shall consist of slip pipes a sleeve pipe , two (2) rubber rings and housings and accessories , and shall have flanges at both ends. Each slip pipe shall have the continuous ring type reinforcing rib and flanged end , slip pipes ands sleeve pipes shall be fabricated from steel sheets or plates , having a minimum yield point of 2200 kg/cm^2 (216 N/mm^2)

b. Rubber ring housing shall be made of ductile, iron casting Rubber ring shall be styrene butadiene rubber (SBR) Reclaimed rubber shall not be used.

4. Coatings And Linings

a. All exterior surfaces of mechanical flexible joints shall, unless otherwise specified, be painted in accordance with the TECHNICAL SPECIFICATIONS.

b. All interior surfaces of mechanical flexible joints and surfaces of slip pipes where they may contact with handling liquid shall be lined with an epoxy system or coal tar epoxy system.

C. Rubber Flexible Joints

1. General

a. Rubber flexible joints shall be designed to withstand all pipeline forces and all combination of forces due to expansion and contraction, shear deflection, distortion and others causes. Rubber flexible joints are classified, as specified in the following Sub section 3), into two (2) types: Type A and Type B. Type A shall be used for all cases except where the use of Type B is specified. Type B shall be used for adjustment of alignment and level of pipelines as specified or shown on the Drawings.

2. Design Requirements

a. Rubber flexible joint, Type A and Type B, shall be designed and manufactured to meet the operating conditions and design requirements as enumerated and tabulated below:

- Two (2) meter depth of earth cover, of which the unit weight is 2.0 ton/ms, plus a 20 ton truck loading.
- Minimum shear deflection of 100 mm.
- The maximum laying length of rubber flexible joint shall be less than 1.500 mm for all sizes up to 1.88 mm.

Type A Operating Conditions and Design Requirements

Nominal Diameter (mm)	Min. Allowable Expansion (mm)	Min. Allowable Contraction (mm)	Min. Allowable Shear Deflection (mm)
40	13	15	10
50	17	19	13
65	19	21	15
80	21	23	16

100	24	26	20
125	26	28	24
150 to 300	44	56	50

3. Construction and Materials

   a. Rubber Flexible Joint, Type A

   Rubber flexible joint, Type A, shall be cylindrical reinforced rubber body having steel pipes with a flange at both ends of the body. Steel pipe and flange shall be fabricated from steel sheets or plates. Steel sheets or plates shall have a minimum yield point not less than 2.20 kg/cm^2 (216 N/mm^2).

   b. Rubber Flexible Joint, Type B

   Rubber flexible joint Type B , Shall consist of cylindrical reinforcement rubber body , a neck flange at both ends and stud bolts and nuts . The joint shall be so designed that any interior ferrous surface does not contact with handling liquid in service and lined with the rubber The rubber used in fabrication or the rubber body, which will be in service with chemical or other liquid specified, shall be suitable type of synthetic rubber or rubber lined with Teflon or other suitable materials as approved by the Engineer The neck flange shall be made of steel. An aluminum alloy neck flange may be used under the approval of the Engineer

   c. Coating and Linings

   Coating and linings for ferrous material to be used for rubber flexible joints, Type A and Type B shall conform to the requirements specified

D. Sleeve Couplings

1. General

   a. Sleeve couplings shall consist of middle ring, two (2) followers, and bolts and nuts for assemblage of coupling.

2. Construction and Materials

   a. Middle ring shall be of sizes to fit the pipes and fittings furnished.

   b. Middle ring and follower in sizes 300 mm and smaller shall be of steel sheets or plates or ductile iron. Those in size 350 mm and larger shall be of steel sheets or plates as specified above.

   c. Gaskets shall be styrene butadiene rubber (SBR). Reclaimed rubber shall not be used. Bolts and nuts for the coupling shall be of the same materials as the sleeve as specified above. Length and minimum thickness of the middle ring shall conform to the following requirements.

Nominal Diameter (MM)	**Min. Length of Middle Ring (MM)**	**Min. Thickness of Middle Ring (MM)**

150	160	7.9 (9.5)
200	160	7.9 (11.5)
250	160	9.5 (11.5)
300	160	9.5 (11.5)
350 to 800	177.8	8
900	177.8	8
1,000 & 1,100	200	12.5
1,200 & 1,350	250	12.5
1,500	250	12.5
1,600 to 1,800	250	12.5

Note: ( ) Indicates thickness of iron casting middle ring.

3. Joint Harnesses

   a. Joint harnesses shall be provided on pipes or fitting where specified or shown on the drawings. Joint harnesses shall consist of stud bolts, and gusset plate with back and front plate or ring. Joint harnesses shall be shop fabricated and welded on pipes or fittings; fillet welding of joint harmesses will not be permitted unless otherwise specified.

4. Coatings and Linings

   a. All exterior surface of middle ring and followers with bolts shall, unless otherwise specified, be painted in accordance with TECHNICAL SPECIFICATION.

   b. All interior surfaces of middle ring shall be lined with epoxy system or coal tar epoxy system.

E. Victaulic Couplings

1. Victaulic; couplings shall be malleable iron casting or ductile iron casting and shall be designed to provide a manual connection by engaging the coupling shoulders on pipe ends which arc grooved of banded and machined to fit the coupling dimension The coupling shall enclose a sealing gasket, which will provide a watertight connection and allow for expansion and contraction of the joint and reasonable deflection, Two or more bolts shall be used to assemble the coupling .

2. Victaulic coupling in size 300 mm and smaller shall be either grooved or shouldered type and that in size 350 mm and 900 mm shall be shouldered type .

3. Gasket shall be styrene butadiene rubber (SBR). Reclaimed rubber shall not be used.

4. The interior and exterior corrosion protection for the surface of the coupling shall be consistent with the provisions for the exterior protection of the associate pipe.

Chapter 3

BASIC MECHANICAL MATERIALS AND METHODS

PART 1: GENERAL

2.3 WORK INCLUDED

A. This section specifies general requirements applicable to all equipment to be supplied.

B. All requirements of this section shall apply to the equipment covered.

C. Contractor shall provide all labor, materials, equipment, and incidentals necessary to furnish and install pipe hangers and supports, including, in general, all metallic hanging and supporting devices and all concrete piers and supports for supporting piping.

2.4 QUALITY ASSURANCE

A. The equipment shall be manufactured in accordance with established practice. All the components shall be finished as required by their importance, position and destination.

B. The manufacture shall be sound, without any faults likely to impair their ability to fulfill their purpose:

1. Equipment shall be designed in compliance with up-to-date practice, with particular attention to the operational requirements of reliability and safety.
2. Equipment design shall take into account control and maintenance operations as well as operating indents.
3. The general aesthetic appearance shall be studied and shall blend in with the overall architecture of the structures.

C. All materials shall be tested in compliance as per ASTM or approved equivalent standards.

2.5 SUBMITTALS

A. Contractor shall submit shop drawings including piping isometric and schedules of all pipe hangers and supports.

B. Shop drawings shall show size, details and thickness of all materials and all installation details.

C. Contractor shall submit samples of materials and items to be supplied under this section per the written direction of the engineer. The contractor may submit manufacturer's catalogs in lieu of samples only upon the engineer's approval.

PART 2: PRODUCTS

2.1 MATERIALS

2.1.1 General

A. Materials shall be new and of first class quality.

B. Rolled and cast steel shall be of good quality and free from blow or shrinkage holes, porosity, cracks or other defects.

C. The Contractor shall indicate in the calculation notes the quality of the materials with reference to ASTM standards, and their mechanical and chemical properties. Such information shall be given for all materials used in the construction of the main items of equipment.

D. Cast iron: no cast iron will be accepted for pieces of equipment submitted to internal pressure valve bodies, except for pump casing where ductile iron type Cl shall be accepted.

2.1.2 Hangers

A. All overhead hangers shall be provided with turnbuckles supported by threaded hanger rods from inserts in the concrete. Overhead hangers, turnbuckle hanger rods and inserts shall be galvanized steel. Hanger rods shall be machine threaded and rod sizes shall conform to the following table.

Pipe Diameter (mm)	Hanger Rod diameter (mm)
80 & smaller	10
100 & 150	12
200 & 250	16
300	19

B. Where support is from walls or columns, welded steel brackets with U-bolts shall be provided. U-bolt sizes shall conform to the following table.

Pipe Diameter (mm)	Hanger Rod diameter (mm)
80 & smaller	10
100 & 150	12
150 & 300	16

C. Wherever practicable, PVC piping and chemical feed piping shall be supported by channel supports.

D. Threads for all nuts, bolts and rods shall conform to Egyptian Standard Ministry Decree No.268 (1988) and later decrees.

2.2 EQUIPMENT

2.2.1 General Provisions for Equipment Design

A. Wear

1. Contractor shall be considered to be fully aware of the properties of the wastewater and the atmospheric conditions and, accordingly, under normal operating conditions, the equipment supplied shall not be subject to any abnormal wear.

2. All parts of equipment subject to water induced wear shall be provided with interchangeable parts that can be easily refilled by welding or replaced. These interchangeable parts shall be made from a material selected in relation to the intended use and the probable wear of the part. The contractor shall indicate the composition

and properties of the materials used on the basis of analyses carried out the suppliers. He shall specify the type of electrode suitable for refilling by welding if this process is used.

3. Design of bearings shall be such that no friction induced corrosion shall occur. The absence of any such wear will be checked at the end of the period of guarantee during equipment inspections.

4. All electrical equipment parts liable to normal or accidental wear shall be designed to resist the action of atmospheric agents and climatic conditions.

B. Noise and Vibration

1. No harmful or objectionable noise vibration shall be generated by the equipment.

2. The plant shall be designed and constructed to operate with the least practicable amount of noise. The employer would aim to achieve the following:

   a. General noise levels within the building or structure containing the Works not exceeding a noise rating of NR80 over the active band mid-frequency range between 62.5 and 8000 Hz in accordance with ISO 1996 / 1-1982 for full habitual exposure of both maintenance and construction staff in

   b. Noise levels in control rooms such that good speech communication is possible and mental concentration is not hindered. It is therefore intended that the noise level in the control room shall conform to ISO NR 40 over the active band mid-frequency range between 250 and 2000 Hz.

3. Attention shall be paid to reducing the air and/or structure-borne noise that may arise from any item of plant supplied under the Contract. Tests to determine the near-field direct sound pressure levels in an agreed number of active bands shall be undertaken by the Contractor after commissioning of the plant at points about 1 m from the plant item concerned, in horizontal and axial planes.

4. Should it not be possible to reduce the noise produced in the item concerned to the above mentioned criteria, the Contractor shall provide at his own cost approved noise attenuating devices to reduce the noise to a level to be approved by the Engineer.

5. Where appropriate, the Contractor shall supply details of the noise produced by the plant supplied under this Contract. Such details shall be in the form of active band sound levels giving reference levels and an indication of directivity.

6. In locations where it is necessary for operational attendants to make routine examinations closer than 1 m to an accessible part of a running machines or inside a noise attenuating enclosure whereby he will be subjected to sound pressure levels significantly greater than those specified the Employer will wish to adopt hearing protection devices. The Contractor is required therefore to draw specific attention to portions of the Plant where sound pressure levels of NR 95 and above may be encountered.

7. Provision shall be made for access to and protection of the equipment so as to ensure safety during operation, maintenance and inspection. Such provision is to be made at the locations and in the positions approved by the Engineer.

8. The Contractor shall supply all catwalks, platforms, ladders, railings, trap-doors, manholes, and access hatches necessary to make access to the equipment easy and safe for the maintenance staff.

9. The Contractor shall submit to the Engineer for approval his proposals for the passage of gutters and for the locations of trap-doors, platforms, access doors and ladders, together will all dimensions of spaces to be allowed for the passage of equipment.

10. All rotating parts such as wheels, shafts, transmission belts and all live electrical equipment shall be suitably protected by metal housings.

C. Arrangement of operating equipment

1. No manual controls for lifting or pulling maneuvers shall require a force of more than 200 newton's, and no manual controls involving the operation of a wheel crank shall require a force of more than 100 newton's.

2. Wheel cranks shall be located approximately 1 m above floors or platforms.

3. The controls and measuring instruments shall be readily accessible, without any need for special equipment, and clearly marked with identification numbers.

D. Handling and dismantling

1. Equipment shall be designed for easy dismantling and maintenance operations.

2. Dismantling and maintenance of electrical equipment shall be possible without stopping or disturbing other equipment in its vicinity.

3. All equipment or parts of equipment designed to be dismantled and handled shall be provided with:

   a. Lifting rings, lugs, hoisting collars

   b. Silnys, chassis and special handling apparatus such as grappling beams, monorails, trolleys. Jacks, pulley and ratchet systems, etc.

   c. Special withdrawing screws appropriately placed and in sufficient numbers for the dismantling of the relevant parts.

4. For heavy components, the Contractor shall provide special facilities for lifting each component; the Contractor shall also provide the necessary lifting gear for this equipment such as manually or electrically operated monorail hoists, hydraulic jacks. Etc.

5. The above equipment shall be included in the Contractor's supply and shall be retained by the Employer.

E. Interchangeability

1. All machined parts included in winches, pumps, gears, etc. and all moving parts in general, shall be interchangeable and capable of being easily erected on a similar type of apparatus.

2. For all the contract equipment, all electrical or hydraulic apparatus, equipment, instruments and accessories (for air, water or oil circuits) of the same rating and

designed to perform the same functions or operate under comparable conditions within a given operating range, shall be identical and inter intangible as far as possible.

3. If certain modifications are made to the equipment during manufacture or erection, these modifications must be submitted for the Engineer's prior approval and shall be made to all the equipment of the same type.

4. At his own expense, the Contractor shall keep for a minimum period of ten years all the manufacturing drawings and all design data likely to be of use in making repairs or replacing components of the equipment.

F. Temperature rise

1. The rise in temperature of metal parts of bearings, thrust bearings, reduction gears and other mechanical systems shall not exceed 40°C above the ambient temperature or, in the case of outdoor equipment, 40°C above the outdoor temperature in the shade.

2. The rise in temperature of lubricating oil measured around the metal parts quoted above shall not be more than 30°C above the outdoor temperature in the shade.

G. Lubrication

1. Lubrication devices and systems are included in the supply. A self lubricating system, preferably comprising a layer of polytetrafluoroethylene (PTFE) or similar material cladded on a stainless metal support bushing. Alternative lubricating bearing material shall be submitted for the Engineer's approval.

2. Self-lubricating systems will be provided wherever possible and are mandatory for submerged or temporarily submerged equipment unless the loads applied prevent their use.

3. Self-lubricating systems for submerged or partially submerged parts shall be provided with protective seals.

4. The systems proposed shall be of a proved and referenced design. References shall be supplied by the Contractor.

H. Operating speed and loads

I. The operating speeds defined in the technical specifications shall be guaranteed under normal operating conditions and at all loads within a 5% tolerance band. The maximum operating loads specified by the Contractor shall be considered as guaranteed.

J. Nameplates

1. All equipment shall have a permanent corrosion - free nameplate clearly showing all pertinent information regarding the equipment, in the English language including the following :

   a. Manufacturer's name and address.

   b. Name, type serial number and other equipment identification data.

   c. Rating and other design data.

   d. Date of manufacture.

e. Lifting capacity.

2. The lifting capacity shall be indicated on the upper frame of each gantry crane and monorail. The letters and figures shall be sufficiently large to be easily legible.

2.2.2 Design of Miscellaneous Equipment

2.2.2.1 Auxiliary Pipe Work and Pressure Tanks

A. General

1. Pipe work shall be supplied with the corresponding flanges, nuts and bolts threaded unions isolating valves (cast iron excluded) supports and anchoring.
2. Pipe work designs shall comply with the following values
   a. Slope greater than 1 % for the drainage lines.
   b. Water and oil flow velocities not to exceed 4 m/s.
3. Pipe work embedded in concrete shall systematically tested under pressure before concreting. All pipe and seals or blank flanges necessary for these shall be provided by the Contractor. No pipe work made of malleable materials, such as lead, copper, etc. shall be embedded in concrete.
4. All flanges and couplings shall be suitably placed to facilitate dismantling of corresponding equipment and appliances, with a sufficient number of isolation valves to avoid loss of fluid when partial dismantling work is carried out.
5. All pipes shall be installed in order to be easily dismantled for maintenance.
6. Flanges and couplings shall be suitably placed to facilitate dismantling. These flanges and couplings shall be indicated on drawings, with the dimensions.

B. Tests

1. Pressure tanks and pipe work shall be tested at a pressure at last 50% greater than the maximum operating pressure.
2. Free surface tanks and basins shall be tested for water tightness before painting.
3. They shall be filled with water for 24 hours and welded joints shall be hammered.
4. The water tightness of the welds shall be tested with compressed air and a soapy solution, or by any other method approved by the Engineer.

C. Tightness of water and oil circuits

1. All bearings, oil, water and pipes, pumps and other associated apparatus shall be perfectly tight. No water air oil or grease leak shall take place. Any condensation and possible leakage shall be collected and drained off. The design shall be such that no oil splashes or vapor will reach electrical equipment.

D. Brakes

1. All braking mechanisms whether of the clamp or disc type whether hydraulically or electromagnetically operated shall exert a braking torque of at least 1.5 times the nominal driving torque. The brakes shall also be capable of operating 600 times/hour

(except for the powerhouse overhead cranes where the brakes shall be capable of operating 200 times/hour).

E. Couplings

1. Coupling between electric drive motors and the various types of driven equipment shall be of the semi-elastic type and shall have a service factor of 1.5.

F. Winch or hoist drums

1. All drums shall be grooved
2. The drums shall be supplied with cable clamps. The cable attachment points on the drums shall be easily accessible.
3. The cable lengths shall be such that when the load is in its lowest position, at least three turns of cable remain on the drum.

G. Pulleys

1. Cable pulleys shall have machined grooves of a depth at least equal to one and a half times the cable diameter. Grooves must be designed to prevent any damage to the cables.
2. The pulleys shall be made of steel (cast iron is not acceptable).
3. The pulleys, lifting hooks and pulley assemblies shall be designed with a safety factor greater than that used for the cables.

H. Lifting hooks

1. Lifting hooks shall be of forged or cast steel, or of welded plate. There must be no sharp angles or curvatures of small radius, which could damage the cables. The hooks shall be supplied with hook safety catches to prevent any rope from becoming unhooked.

I. Chains and cables

1. The threads of cable strands shall be made of galvanized steel.
2. The cables shall have a metallic central core and shall be grease impregnated inside and outside so as to resist corrosion and wear.
3. The cables shall be rolled up to a diameter conforming to their characteristics for shipment and storage purposes.
4. If during any particular maneuver several lengths are used the tension on each cable shall be equally distributed by means of pulleys or balancing beams. The only exception to this rule will be the case where such a procedure could cause the lifted item to jam. In such a case, the possible overload due to lack of balance shall be taken into account at the cable design stage.
5. L s, end sockets and other attachments for fastening the cables shall be galvanized and capable of withstanding 90% of the guaranteed breaking stress of the cables to which they are fixed. The cable manufacturers shall supply test cables of sufficient length so that samples may be cut off for destructive tensile tests Costs of these tests shall be borne by the supplier.

6. The minimum cable breaking load shall be equal to at least six times the maximum design load of the chain.

J. Bolts, nuts, screws

1. All bolts, nuts and screws in contact with water or in a damp atmosphere shall be made of stainless steel. Particular care shall be taken to avoid contact corrosion. Threads submitted to vibrations shall be especially treated with special resins.

K. Shims

1. All shims to be used shall be protected from corrosion by cadmium plating, sherardization or by any other process approved by the Engineer.

L. Piping

1. All pipe work is to be corrosion resistant. All pressure hoses are to be metal sheathed with all connections cadmium or chromium plated.

2.2.2.2 Rail Tracks

A. At the civil works joints rail tracks shall be fitted with fishplate type joints.

B. Rail tracks shall be grounded and connected to the general grounding system. Fishplates on each side of a joint shall be electrically connected.

C. Buffers shall be installed at each end of the rail tracks. These buffers shall be of welded construction and designed to absorb and resist the impact of the relevant handling equipment.

D. D. For all anchoring, use of "fish tail" systems is strictly prohibited.

2.2.2.3 Anchors

A. For all anchoring, use of "fish tail" systems is strictly prohibited.

2.2.2.4 Design Criteria

A. In his design calculations, the Contractor shall consider the most adverse conditions that shall have to be withstood by the equipment, whether in operation or during manufacture, transport and erection.

B. The design calculations and conditions of loading of handling equipment shall conform to those given in the Rules for design calculation of lifting equipment published by the FEM.

1. Loading conditions

a. Loads taken into account:

- The nominal load on the hoist for gates and gate fittings, under loaded conditions, shall be equal to the maximum load under normal operating conditions.
- Loads induced by exposure of the equipment to the sun under the climatological conditions of the site.
- Wind-induced loads :

a- Maximum wind speed with equipment in operation: 80 km/h

b- Maximum wind speed with equipment out of operation: 150 km/h

- Test loads :
  a. Static tests, additional load equal to 50% of the nominal load;
  b. Dynamic tests, additional load equal to 20% of the nominal load.
- Earthquakes :

  Two levels of seismic loads shall be considered:

  a. OBE: operating basic earthquake;
  b. MCE: maximum credible earthquake.

  The accelerations to be taken into account are:

  a. Horizontal accelerations:

     MCE H 0.1 g.

b. Load cases

The load cases shall conform to those laid down by the FEM for case Ill "Equipment subjected to exceptional forces", the following combinations shall be added:

- Equipment in operation with wind and earthquakes.
- Equipment out of operation with maximum wind and earthquakes.
- Loads possibly occurring on the entire equipment or on parts there of during manufacture transport or erection.

2. Maximum acceptable stress values

Except where particular indications are given for a type of structure or equipment, the following values shall be considered:

i. Rules published by the FEM, mentioned above and C.M. 66 rules.

The said rules are completed by the following limitations:

- Normal maximum acceptable level:
  a. of the tensile stress or compressive force on the steel : 60% of the limit of elasticity ;
  b. of the equivalent force (case of parts subjected to forces from different directions) : 75% of the yield strength.
- Exceptional maximum acceptable level
  a. of the tensile stress or compressive stress in the steel : 75% of the yield strength
  b. of the equivalent force (case of parts subjected to forces from different directions) : 90% of the yield strength.

For the bearings and pivot points provided with self-lubricating sleeves, the mean specific pressure between the sleeve and the shaft shall not exceed 450 bars.

3. Loads on concrete

   i. The maximum acceptable compressive load transmitted from the structures to the concrete shall comply with C.M. 66 rules article 15.121.3.

4. The webs of the steel beams participating in structural strength shall be subjected to a warping tolerance following standard DIN 4114 and complementary provisions.

2.3 FABRICATION

2.3.1 Cast Steels and Castings

A. Before any part is cast, drawings of the major items showing the proposed locations of the samples which are to be sent for mechanical and chemical tests, shall be discussed between the Contractor and the foundry.

B. Blow holes and all other such defects which become apparent after cleaning or machining must be ground to sound metal before any rectifications are undertaken.

C. Castings shall not be twisted nor show any other form of distortion, nor increase in their dimensions (above that already taken into account) which could cause inference with other parts. The metal structure of the castings shall be homogeneous and free of all non-metallic impurities.

D. If at any point of a critical section the casting exhibits any unacceptably high concentration of impurities or alloying elements, the part will be rejected.

E. Major castings shall be submitted for ultrasonic inspection or radiographic examination where ultrasonic testing is unpractical or gives doubtful results. The above mentioned tests shall be complemented by magnetic particle inspection or dye penetration tests.

F. The Manufacturer shall establish a quality sheet for each major casting.

G. All casting defects not in accordance with the quality sheet shall be completely eliminated. The importance of the repair will be characterized by the depth of the cavity required to remove all defective metal. The procedure for the inspection of the cavity and the repair shall be specified by the Manufacturer in a note to be submitted to the Engineer.

H. Casting defects shall only be corrected by welders of the highest qualification using the best welding techniques. All castings requiring rectification during any stage of the manufacturing process after they have been initially annealed shall, unless otherwise indicated, be re-annealed.

I. Casting defects which require correction by welding shall be shown on a drawing, or by means of photographs in the case of major defect.

- END OF SECTION -

CHAPTER 4

HYDRAULIC GATES

PART-4 GENERAL

4.1 WORK INCLUDED

A. This section of the specifications covers the sliding stop logs and penstocks located at the various locations within each pumping station.

B. Provide all labor, materials, equipment and incidentals necessary to furnish, install and test the miscellaneous sliding stop ςlogs and penstocks as specified herein.

C. The supply shall include the following main items for stop logs:

1. Embedded parts including lateral guide up to the top of the groove.
2. Stop log leaf in two elements.
3. Equipment for storing and holding in position the stop log.
4. The anchoring system of the built in parts embedded in the secondary concrete.
5. The corrosion protection work.
6. The anchoring and support parts to be held or embedded in the primary concrete.

D. The supply shall include the following main items for penstocks:

1. Complete set of embedded parts.
2. Gate leaf.
3. Gate frame.
4. Manual and electrical gate operator.
5. Stem guide and top wall mounting brackets.
6. Corrosion protection work.
7. Anchoring and support parts to be he held or embedded in the primary concrete.

4.2 RELATED WORK

A. Section 15050 Basic mechanical materials and methods.

B. Section 15080 Mechanical Insulation.

C. Section 14630 Bridge Cranes.

D. Section 14620 Overhead Trolley hoist.

E. Section 11310 Screw pumping station Drainage pump.

F. Division 16 Electrical.

4.2.1 Coordination

A. Work under this section shall be coordinated with work covered by the following sections:

1. Civil Engineering works and Building works.
2. General Requirements.

4.3 SYSTEM DESCRIPTION

4.3.1 Stop Logs

A. The stop logs will be of the sliding type and welded construction, and to facilitate the operation they will be made in two sections.

B. The stop logs will be fitted with seals on all four sides.

C. The stop logs will be operated under balanced water pressure conditions only by means of a stop log lifting attachment for connection to the hoist. The lifting attachment will be the same for operating any stop logs of the pumping station.

D. For the opening the stop log shall be lifted under balanced water pressure conditions by means of by - pass valve to be mounted on the lower element and operated from the top.

E. When not used the stop log is stored and held in position in the upper part of the gate sump by means of a manual storage device.

F. The stop logs will be operated by means of :

1. A crane for the stop logs located at the reception and outfall chambers.
2. A monorail for the stop logs located at the inlet pump sump.
3. A removable lifting davit for the stop logs located at the screw pump discharge channels.

G. Design Criteria:

1. Refer to Section 15050 Basic mechanical materials and methods.
2. The stop logs shall be designed to withstand without damage an MCE (maximum credible earthquake).

4.3.2 Penstocks

A. The gate shall be designed for operation with seating and / or unseating head water conditions as indicated on Tender Drawings.

B. Where required penstocks will be operated by means of electrically driven actuators with integral reversing starters. The motor drive will be automatically disengaged when under manual operation.

C. The gates shall be designed to ensure tight closure whilst maintaining freedom of the leaf movement during operation and minimizing sliding wear of the sealing faces.

D. Design Criteria:

1. The nut in the gate will be of rising spindle penstocks, and the hand wheel of non-rising penstocks.
2. The penstocks shall be designed to withstand without damage an MCE.
3. The operating gear of all penstocks will be capable of opening or closing the gate against an unbalanced head equal to the maximum working pressure.
4. Hand wheels will be rotated clockwise to close the penstocks and clearly marked with the words (Open) and (Close) with arrows in the appropriate direction.
5. Penstocks will be fitted with position indicators which will indicate whether the penstock is fully open or closed.
6. Hand wheel and reduction gearbox will be designed for easy hand operation.
7. The gear boxes will be oil or grease filled.
8. Where required penstocks shall be fitted with flush inverts to give a smooth flow passage at the bottom of the penstocks.
9. When the distance between the sill and the base floor is important the extension rod will be fitted with a guide bearing every 2 m.
10. Each actuator will be fully weather proof and fitted with anti condensation heater upper and lower limit switches and torques switches.
11. All local controls will be protected by a lockable cover.

4.4 QUALITY ASSURANCE

A. Inspection and testing of raw materials used in the manufacture of the equipment the Contractor shall supply certificates of mechanical tests and chemical analysis.

B. Inspection and testing of standard products: the Contractor shall supply certificates of routine tests.

C. Workshop inspections and tests:

1. At the end of manufacture, the stop log shall be presented unpainted for checking. The seals and the embedded parts shall be presented separately.
2. Stop logs, embedded parts, gate and embedded parts:

D. The surface appearance of embedded parts shall be examined and their dimensions checked. Rolling sliding and plate sealing surfaces shall be perfectly flat and smooth.

E. All dimensions of stop log members shall be checked.

F. The operation of by pass valves shall be checked.

G. The Engineer reserves the right to participate in these tests.

1. **Welds:** Refer to Section 15050 Basic mechanical materials and methods.

4.5 REFERENCES AND STANDARDS

A. DIN 19704 Principles for computation of steel hydraulic plant.

B. DIN 19705 - Recommendation for the design construction and erection of hydraulic steel structure equipment.

C. DIN 4114 Steel construction Stability analysis Buckling Lateral buckling Local buckling.

D. DIN 1045 Reinforced concrete structures: design and construction.

E. NF 46.503Medium and heavy plates. Tolerances on dimension and excess weight.

4.6 SUBMITTALS

4.6.1 General

A. Refer to General Requirements.

B. Inspection and testing of raw materials used in the manufacture of the equipment: the Contractor shall supply certificates of mechanical tests and chemical analysis.

C. Inspection and testing of standard products: the Contractor shall supply certificates of routine tests.

4.6.2 Guarantees

4.6.2.1 Vibration

A. The operation of the stop log and gate shall be guaranteed free of vibration. No tolerances are allowed.

4.6.2.2 Sealing

A. The equipment shall satisfy the guarantees specified hereunder without any special means having to be used for sealing.

B. Local leaks and average leaks per linear meter of seal shall not exceed the following values for stop logs:

1. Local leaks: 0.25 liters per second.
2. Average leaks: 0.10 liters per second.

C. The leakages shall not exceed 0.02 I/s per linear meter of seal for gates.

PART-5 PRODUCTS

5.1 EQUIPMENT

5.1.1 Stop Logs

5.1.1.1 Embedded Parts

A. The embedded parts shall include:

1. Lateral guide rails extending over the full height of the slots.
2. The sill mode of steel section.
3. The stop log storage system shall be designed to be easily operated from the

platform.

5.1.2 Stop Log Leaf

A. Stop log shall be of welded construction in two sections.

B. The leaf shall have upstream skin plate and upstream seals.

C. The leaf shall be supplied with the necessary supports for storage of the stop log.

D. The upper girder of the leaf shall accommodate the necessary lifting attachments for connection to the cable hoist as well as the by-pass operating system used to balance the upstream and downstream pressures across the stop log.

E. Two guide blocks shall be provided on each side of each stop log or section. Their location shall be such that the highest and lowest bumper plates are separated from each other as much as possible. The stop log shall be provided with sufficient space for sideward movement but the bumper plates shall hold the stop log in a centered position, no more than 5 mm from the centerline of travel.

F. All stop log members shall have a minimum clearance from embedded parts of 10 mm.

5.1.3 Penstocks

5.1.3.1 Embedded Parts

A. The embedded part will be of welded construction.

5.1.3.2 Penstocks

A. The penstocks shall be of welded construction. The frame and gate shall be in stainless steel grade 316 or better.

B. Non ferrous metal sealing faces shall be formed from accurately machined gunmetal or bronze strips bedded and fixed to machined recesses by non corrodible countersunk screws. The faces of the strips will be then brought together in the operating position and hand scrapped to a watertight finish.

C. Rubber sealing faces will be formed from synthetic rubber suitably shaped to interlock grooves in the frame or door and will be securely bonded thereto.

D. The nut in the door of non rising spindle penstocks shall be gunmetal and the hand wheel shall be high grade cast iron GG25 or D.C.I GGG40.

PART-6 EXECUTION

6.1 INSPECTION

A. Contractor shall check the setting and alignment of pre-embedded parts as well as the dimensions and setting of recesses in the civil works for embedded parts.

B. Contractor shall check the dimensions and setting of the sluice.

6.2 SPARE PARTS

6.2.1 Stop Logs

A. Contractor shall specify and supply the special tools required for stop log maintenance.

B. Contractor shall supply the following spare parts at least:

1. One complete set of seals with 50% stainless steel bolts for the stop log leaf.
2. One complete set of seals for the by pass valve.

6.2.2 Penstocks

A. Contractor shall specify and supply the special tools required for gate maintenance.

B. Contractor shall supply the following spare parts:

1. One complete set of seals with 500% of the stainless steel bolts for the gate leaf.

6.3 FIELD QUALITY CONTROL

6.3.1 Pre and Post Concreting Inspection

A. Position of the sill.

B. Distance between the lateral embedded parts.

C. Perpendicularity of the lateral embedded parts with the sill.

D. Flatness of the embedded parts verticality horizontality.

E. Position of storage system at the top of the grooves.

6.3.2 Stop Logs

6.3.2.1 Blank Test

A. Testing of the various operations required for sluice closure and opening (Seal friction surfaces shall be wetted).

B. Checking the position of seals with respect to lateral embedded parts and sill.

C. Checking the position of lateral guide systems with respect to lateral embedded parts.

D. Checking the position and operation of the storage system.

E. Examination of paintwork.

6.3.2.2 Final Test

A. With the water levels available at the time of the tests:

1. Inspection of seals.
2. Testing of the various operations required for closure and opening of the sluice.
3. Examination of paintwork.

6.3.3 Penstocks

6.3.3.1 Dry Tests

A. Testing of the various operations required for sluice closure and opening seal friction surfaces shall be wetted.

B. Checking the position of seals with respect to embedded parts.

C. Checking the position of lateral guide systems with respect to embedded parts.

D. Checking the position and operation of the wedging system.

E. Examination of paintwork.

6.3.3.2 Final Tests

A. With the water levels available at the time of the tests:

1. Inspection of seals.
2. Testing of the various operations required for closure and opening of the sluice.
3. Examination of paintwork.

CHAPTER 5

VALVES

1.SCOPE OF WORK

A. The Contractor shall provide all labor, materials equipment sand incidentals necessary to furnish and install. ready for operation all valves with operators. accessories, paint, spare parts, tools. operating manuals and appurtenances as shown on the drawings and as specified

herein the materials and equipment shall be the product of an established and reputable manufacturer who has had experience in the manufacturer of the type of equipment herein specified The manufacturer shall demonstrate to the satisfaction of the Engineer that his products have successfully been in operation for a minimum of five (5) years

B. Before installation of any valve, the Contractor shall submit an affidavit from the manufacturer certifying that each valve meets the requirements of this Specification, along with a record of the specified tests to the Engineer for approval. No valve shall be installed prior to approval by the Engineer.

2. DRAWINGS

A. The Contractor shall submit detailed working and shop drawings and schedules of all valves, accessories and appurtenances in.

B. Shop drawings shall include, but not be limited to the following:

a. Lists and schedule of material

b. Details of proposed joints and harnesses

c. Names of suppliers

d. Dates of delivery of materials to the jobsite

C. Shop drawings shall show size, dimensions, fabrication details materials and thickness of all items and all installation details.

2. PAINTING

A. All valves gates and appurtenances unless otherwise specified shall be shop primed on the exterior in accordance with the TECHNICAL SPECIFICATIONS.

B. All valves, gates and appurtenances unless otherwise specified shall have an interior ferrous port and except for finish or bearing surface painted with two (2) coats of epoxy paint or coal tar epoxy paint of coal tar epoxy paint. The paint shall conform to AWWA C210 or shall be certified by the recognized public health authorities of livings in potable water service.

4.GENERAL CONSTRUCTION

A. All valves shall have the name and/or mark of manufacture and they shall be designed cast in raised letters upon some appropriate part of the body,

a. Year of manufacturing 01 (means 2001)

b. Working pressure, 9 K (means 9 kg/cm2) and

c. Arrow direction for valves designed for one way flow only.

B. Valve ends shall be flanged ends except where otherwise specified.

C. Thickness of flanges shall be determined based on the working pressure specified, as well as the pipe lines site test pressure, which shall be 1.5 times the working pressure) and shall conform to internationally accepted standards or the Contractor shall determine the flange thickness and shall submit his design calculations.

D. All materials, which will be specified hereunder, shall conform to ISO or other internationally accepted standards.

E. Valves shall be equipped with hand lever, hand wheels" chain or hand pneumatic or electric operators as required . Unless otherwise specified manual operation valves shall have hand wheels. Operators shall have arrows cast thereon to indicate the direction of rotation for opening the valve.

F. All pipe connection openings shall he capped to prevent the entry of foreign matter prior to installation

G. Valves 50 mm in site and smaller shall be all bronze unless otherwise specified except for hand wheels which shall be of cast or malleable iron and provide with screw ends

H. The minimum working pressure of valve shall be as specified herein unless otherwise shown in the valve schedules.

Installation

A. All valves, gates and appurtenances shall be installed in accordance with manufacturer's directions. The installation shall be true to alignment and rigidly supported.

B. Pet cocks shall be installed at all points shown of called for on the drawings and at any other location where air binding of pipe lines might occur.

C. All valve operators shall be installed according to the manufacturer's recommendations and as specified herein.

D. Before setting the items specified the Contractor shall check all plans and figures, which have a direct bearing on their locations, and the Contractor shall be responsible for the proper location of these valves and appurtenance during the construction of the structures.

5.GATE VALVE

General

A. The following gate valves shall be specified hereinafter.

   a. Gate valves (80 mm to 1.000 mm)

   b. Resilient gate valves (80 mm to 300 mm)

   c. Bronze gate valves (80 mm and smaller)

   d. Stainless steel gate valves (815 mm to 300 mm)

B. Unless otherwise specified all valves except gate valves, 600 mm and larger shall be equipped with hand wheels, and gate valves, 600 mm and larger, shall be equipped with manual operators with hand wheels.

References

The following standards are referred to.

AWWA C210: Liquid Epoxy coating system for interior and Exterior of Steel Water Pipelines

AWWA C213:	Fusion-Bonded Epoxy Coating for the Interior and Exterior of Steel Water Pipelines
AWWA C500:	Gate Valves, 3 through 48 inch, NPS, for Water and Sewage Systems
AWWA C509:	Resilient-Seated Gate Valves, 3 through 12 inch NPS, for Water and Sewage Systems
BS 5150:	Metric Specification for Cast Iron Wedge Gate Valves for Waterworks Purpose.
BS 5163:	Metric Specification for General Purpose Cast Iron Wedge Gate Valves.

Gate Valves (80 mm to 1000 mm)

A. Gate valves shall be designed and manufactured in accordance with AVVWA C500 or BS 5163 and BS5150, or other internationally accepted standards Working pressure shall be 9.0 kg/cm2 for valves.

B. The valve body and bonnet shall be of cast iron or ductile cast iron and the valve shall be of spindle outside screw type.

C. The stuffing box shall be of the same materials as the body, and shall be in the open position. The depth of the stuffing box shall be not less than the diameter of the valve stem- Packing for the stuffing box shall be made of asbestos or other suitable materials approved by the Engineer,

D. Hemp or jute packing shall not be used. O-ring stem seals may be used, subject to the approval of the Engineer and these seals shall have a minimum of two (2) "0" ring seals, of which at least one (1) shall be above the stem collar and replaceable under full working pressure while the valve is in the fully open position.

E. Valve stems shall be cast, forged or rolled bronze or stainless steel, type 403 or 420.

Resilient-Seated Gate Valves (800 mm to 300 mm)

A. Resilient - seated gate valves (hereinafter called RS called RS type gate valve) shall be designed and manufactured in accordance with AWWA C509 or other internationally accepted standards. Working pressure shall be 9.0 kg/cm2.

B. RS type gate valves shall be cast iron-body resilient - seated gate valves with non-rising stems (NRS) and outside screw-and-yoke (OS & Y) rising stems. Valves shall be designed to provide and unobstructed waterway having a diameter of not less than the full nominal diameter of the valve when in the open position.

C. The valve body, bonnet, gate and yoke shall be of gray cast iron or ductile cast iron. The yoke on bonnets shall be integral or of bolted-on construction of such proportions and secured in such a manner that it shall be as strong as other parts of the valve. The design shall be such that a hand cannot be jammed between a yoke and the hand wheel.

D. For stem seals, either gland packing or O-rings, including other pressure-actuated stem seals, shall be provided. The stuffing box or O-ring packing plate shall be of the same materials as the valve body. The depth of the stuffing box shall be not less than the diameter of the

valve stem. Gland packing for the stuffing box shall be made of asbestos or other suitable materials approved by the Engineer. Hemp or jute packing shall not be used. O-ring stem seals shall be designed to have a minimum of two (2) "0" ring seals of which at least one (1) shall be above the stem collar and replaceable under full working pressure while the valve is in the fully open position.

E. Valve stems shall be cast, forged or rolled bronze or stainless steel. Type 403 or 420.

F. All Valves unless otherwise specified shall be equipped with hand wheels.

G. Resilient seats shall be applied to the gate and shall seat against a corrosion-resistant surface. The surface shall be non-metallic, applied in a manner to withstand the action of line fluids and operation of the sealing gate under long-term service. Resilient seats shall be bonded or mechanically attached to the gate. All exposed mechanical attaching devices and hardware used to retain the resilient seat shall be of a corrosion-resistant material.

H. Bolts and nuts to be used for bonnet, packing plate, gland and others shall be stainless steel unless otherwise noted.

I. Will interior and exterior ferrous parts of the valve except for finished or seating surfaces shall be finished with fusion-bonded epoxy protective coating. Fusion-bonded epoxy coating shall be heat activated, chemically cured coating systems conforming to AWWA C213. Total dry film thickness on the interior and exterior surface shall be not more than 0.4 mm and not less than 0.3 mm. respectively.

Bronze Gate Valves (80 min and Smaller)

A. Bronze gate valves shall be designed and manufactured in accordance with approved standard working pressure shall be 9.0 kg/cm^2 Valves shall be equipped with either screwed ends or flanged ends.

B. Valves, in sizes 50 mm and smaller shall be bronze body, screwed bonnet, gate valves having a solid wedge, inside screw and rising stem,

C. Valves in sizes 65 mm and 80 mm shall be bronze body, flanged bonnet, gate having a solid wedge, inside screw and non-rising stem.

D. The body shall be bronze casting or bronze casting having tensile strength not less than 20 kg/mm^2 (196 N/mm^2). Disc shall be bronze casting specified above or copper having tensile strength not less than 32 kg/mm^2 (314 N/mm^2).

E. Stem shall be of copper as specified above.

i. Stainless Steel Gate Valves (15 mm to 300 mm)

A. Stainless steel gate valves shall be solid wedge disc type gate valves with outside screw-and-yoke (OS & Y) rising stems and designed for handling acids. Valves shall have hand wheels and flanged ends. Working pressure shall be 9.0 kg/cm^2.

B. Unless otherwise specified, major parts of the valve such as body, bonnet, stem, disc, gland with gland bolts and nuts, bonnet bolts and nuts and other parts which may come in contact with the handling liquid shall be made of type 316 stainless steel and stainless steel casting.

6.BUTTERFLY VALVES

General

A. The butterfly valves shall be as specified hereinafter.

a. Butterfly valves for water (80 mm to 1.900 mm)

b. Butterfly valves for air (80 mm to 1.000 mm)

c. Wafer butterfly valves for water (80 mm to 500 mm)

d. Wafer butterfly valves for chemical services (80 mm to 500 mm)

B. All valves shall be equipped with manual operators and with hand wheels unless otherwise specified.

References

A. The following standards are referred to.

AWWA C504 Rubber-Seated Butterfly Valves.

ASTM A48 Specification for Gray Iron Castings.

ASTM A126 Specification for Gray Iron Castings for Valves, Flanges and Pipe Fittings.

ASTM A536 Specification for Ductile Iron Castings.

ii. Butterfly Valves For Water (80 mm To 1.800 mm)

A. Valves shall be cast iron or ductile iron body, rubber-seated light-closure butterfly valves and shall be designed and manufactured in accordance with AWWA C504. Valves shall be designed for the maximum nonshock shutoff pressure, 5.0 kg/cm2 or 10 kg/cm2, and a maximum operating torque as shown on the following Table A.

Table (A): Maximum Operating Torque

Nominal Diameter (mm)	Class 5.0 kg/cm (kg-m)	Class 10.0 kg/cm^2 (kg-in)
80	1.7	2.6
100	3.0	5.0
150	7.2	12.8
200	13.1	24.2
250	22,8	44.2
300	38.7	70.5
350	62 2	99.5
400	92.6	142
450	130	205
500	180	280
600	304	484
700	484	754
800	728	1,110

900	1.045	1,605
1000	1.440	2,190
1100	1.930	2,910
1200	2.490	3,800
1350	3.530	5,530
1500	4.840	7,470
1600	5.880	9,130
1800	8.300	12,440

Notes :

- Torque represents maximum capability for which valves are to be applied.
- In each case, numerical class designation is the maximum nonshock maximum non shock pressure, in kg/cm2.
- A 600 mm Class 10.0 kg/cm2 valve is to be designed for a maximum nonshock shutoff pressure of10.0 kg/cm2 and a maximum operating torque for valve of 484 kg-m.
- Valve bodies shall be either cast iron or ductile iron and they shall conform to the following:
- Cast iron: ASTM A126. Class B or ASTM A48. Class 40.
- Ductile iron: ASTM A536, grade 65-45-12.

B. Valves shall have laying length and minimum body shell thickness as shown in the following Table B.

Table (B): Maximum Laying Length and Bod Minimum Shell Thickness

Nominal Diameter (mm)	**Laying Length (mm)**	**Min. Body Shell thickness**	
		Class 5.0 kg/cm (kg-m)	**Class 10.0 kg/cm2 (kg-m)**
80	125	9.4	9.4
100	125	10.2	10.2
150	125	10.9	10.9
200	150	11.7	11.7
250	200	12.7	13.7
300	200	13.7	14.7
350	200	14.7	16.0
400	200	16.0	17.3
450	200	17.3	20.1
500	200	18.0	21.1
600	200	20.3	23.6
700	300	22.9	26.7
800	300	25.4	29.2
900	300	28.7	31.0

1000	300	29.2	33.3
1100	375	31.0	35.3
1200	375	34.8	37.6
1350	375	28.4	41.4

Table (B): Maximum Laying Length and Body Minimum Shell Thickness

Nominal Diameter (mm)	Laying Length (mm)	Min. Body Shell thickness	
		Class 5.0 kg/cm^2 (kg-m)	Class 10.0 kg/cm^2 (kg-m)
1500	375	412	48.0
1600	450	442	50.0
1800	450	50.8	60.3

Notes :

- At no point shall the body shell thickness be more than 12.5 percent below the metal thickness shown in the above table.

C. Valve shafts shall be made of type 302,303,304 or 316 stainless steel or Monel. Valve shafts shall be a one-piece unit extending completely through the valve disc, or of the "stub shaft" type, which comprises two separate shafts inserted into the valve disc hubs. If of distance of at least 1.5 times theshaft diameter.

D. Valves 600 mm and smaller in diameter shall be seat-in-body type. Valves 700 mm to 1800 mm in diameter shall be either seat-in-body or seat-in-disc type, and in either case, seat shall be designed to be replaceable in-line without use of special tools.

E. Rubber seats shall mate with the following seat surfaces, which shall conform to AWWA C504: stainless steel. Monel and bronze. Sprayed or plated mating seat surfaces shall not be used. Deposit seat surfaces may be acceptable if approved by the Engineer.

F. Rubber seat for valves, 600 mm and smaller shall be clamped, mechanically secured, bonded, or vulcanized to the valve body.

G. Rubber seats for valves, 700 mm to 1.800 mm shall be mechanically clamped or secured to the valve body or disc.

H. All clamps and retaining rings for rubber seats shall be of corrosion-resistant material with a maximum zinc content of 16 percent and a maximum aluminum content of 3 percent. All nuts and screws used with clamps and retaining rings shall be of stainless steel.

I. Valve discs shall be of a cast or fabricated design with no external ribs transverse to the flow. The thickness of the valve disc shall not be more than 2.25 times the shaft diameter listed below. Valve discs shall be of cast iron, ductile iron, stainless steel, cast steel, fabricated steel, bronze and alloy cast iron. They shall conform to the standards as specified below.

Cast Iron : ASTM A 126, Class B or ASTM A 48, Class 40.

Ductile iron : ASTM A536, grade 65-45-12

Stainless steel : Type 302, 303, 304 or 316 or other type approved by the Engineer

Others : Conform to AWWA C504.

J. Shaft seals shall be provided wherever shafts project through the valve body. Shaft seals shall be designed for the use of standard split-V type packing, for standard 0-ring seals or for pull-down packing.

K. O-ring shaft shall be contained in a removable corrosion-resistant recess.

Butterfly Valves For Air (80 mm to 1,000 mm)

A. Butterfly valves in air piping shall meet all the applicable requirements specified in the previous sub-section for butterfly valves for water except as otherwise specified herein.

B. Butterfly valves for air piping shall be designed to provide an airtight seal. Rubber seats shall be synthetic rubber suitable for use with air temperatures up to 115 degrees C and all other components shall be suitable for use with the air temperature specified above.

C. All valves shall be equipped with manual operators with hand wheels unless otherwise specified.

Wafer Butterfly Valves For Water (80 mm to 500 mm)

A. Wafer butterfly valves in water piping shall meet all the ,applicable requirements specified in previous sub section for BUTTERFLY VALVES FOR WATER (80mm to 1.800 MITI) except as otherwise specified herein.

B. Valves shall be designed to fit between two pipe flanges and for the maximum nonshock shutoff pressure of 10: 0 kg/cm^2.

C. Valves shall be seat-in-body type and have rubber seat rings, which shall be designed to lap over both faces of the valve.

D. All valves shall be equipped with manual operators with hand wheels unless otherwise specified.

Wafer Butterfly Valves For Chemical Services (80 mm to 500 mm)

A. Wafer butterfly valves in chemical service lines and chlorine service lines shall meet all applicable requirements specified the previous sub-section on butterfly valves for water, except as otherwise specified herein.

B. Valves shall be designed to fit between two pipe flanges and the maximum nonshock shutoff pressure of 7.5 $kglcm^2$.

C. Valves shall be seat-in-body type and have seat rings, which shall be designed to be of sandwich construction of synthetic resin and liquid contact Teflon seat with elastic rubber core.

D. Valve discs shall be coated with Teflon, and all other parts, which may come in contact with the handling liquid, shall be coated with Teflon.

7.CHECK VALVES

General

A. Check valves shall be as specified hereinafter.

   a. Swing check valves (50 mm to 600 mm)

b. Bronze swing and lift check valves (50 mm and smaller)

c. Stainless steel check valves (50 mm to 300 mm)

d. Tilting disc check valves (50 mm to 1.200 mm)

e. Wafer check valves (50 mm to 1.200 mm)

f. Spring loaded lift check valves (25 mm to 400 mm)

B. All check valves except tilting disc check valves, wafer check valves and spring loaded lift check valves shall be constructed so that disc, seat rings and other internal working parts which may become necessary for repairs shall be readily accessible, removable, and replaceable without use of special tools, and designed for removing the valve from the line.

References

A. The following standards are referred to:

API 594	Wafer Check Valves.
AWWA C508	Swing-Check Valves for Waterworks.
	Service, 2 inch through 24 in NPS

Swing check Valves (50 mm to 600 mm

A. Swing check valves shall be cast iron body and disc and bronze seating type The valves shall be designed and manufactured in accordance with AWWA C508 Working pressure shall 10 kg/cm^2 unless specified otherwise elsewhere

B. Valves shall be suitable to operate in a horizontal or vertical position with flow upward, and when fully open the valve opening shall have a net flow area not Icss than the area of a circle with a diameter equal to the nominal pipe size,

C. Valves shall be furnished with hinge arms, levers and springs or weights.

Bronze Swing And Lift Check Valves (50 mm and Smaller)

A. Bronze swing and lift check valves shall he designed and manufactured in accordance with approved standard. Working pressure shall be 9.0 kg/(cm^2, unless specified otherwise elsewhere. Valves shall be equipped with screwed ends.

B. Swing check valves shall be suitable to operate in a horizontal or vertical position with flow upward. Lift check valves shall be suitable to operate in a horizontal position with flow upward when fully open. Both swing and lift check valves shall have a net flow area not less than the area of a circle with a diameter equal to the nominal pipe size.

C. Valves shall be of bronze body, screwed bonnet and disc. Valves shall be designed to have bronze seating or resilient seating. Resilient seats shall be made of Teflon.

D. The body shall be of bronze casting and bonnet and disc shall be of bronze casting or copper. The said bronze casting and copper shall conform to the requirements specified under clause BRONZE GATE VALVES (80 mm and smaller).

Stainless Steel Check Valves (15 mm to 300 mm)

A. Stainless steel check valves shall be straightway, swing type and designed for handling acid. Valves shall have metal to metal scatting. Working pressure shall be 9.0 kg/cm^2.

B. Valves shall be suitable to operate in a horizontal and vertical position with flow upward, and when fully open: valves shall have a net-flow area not less than the area of a circle with a diameter equal to the nominal pipes size.

C. Unless otherwise specified, major parts of the valve. Such as body bonnet disc, hinge with hinge pin and other parts which may come in contact with handling liquid shall be made or type 316 stainless steel and stainless steel casting.

Tilting Disc Check Valves (50 mm to 1.500 mm)

A. Tilting disc check valves shall be of cast iron body and disc, and bronze or stainless steel seating. Valves shall be designed for a working pressure of 9.0 kg/cm^2 and shall be suitable for operation in a horizontal pipeline.

B. Body shall be of two (2) piece construction bolted together. Seat rings shall be mounted on both valve body and disc and shall be made of bronze casting conforming to approved or other stainless steel norms. Mating surfaces of body, seat and disc seats shall be machine finished. Hinge pin shall be of stainless steel specified above. Bushings for hinge pin shall be bronze casting specified above or aluminum bronze casting conforming to the latest standard.

C. Dash pots shall be furnished with valves and designed to have valve opening and closing speed control devices. Dash pots shall be approved by the Engineer.

Water Check Valves (50 mm to 1,200 mm)

A. Water check valves shall be dual plates, two spring - loaded, semicircular plates type. The valves shall be designed and manufactured in with API 594, or other internationally accepted standards.

B. valves shall be designed to fit between two pipe flanges and for a working pressure of 9.0 kg/cm^2 unless specified otherwise elsewhere ,

C. Valve body and plot ,all he of cast iron, ductile non or type 316 stainless steel. Bronze casting plates may be permitted ,Hinge pin. stop pin and springs shall he of type 316 stainless steel. Valves shall have resilient seating in the valve body unless otherwise specified Seat materials shall he Buna-N (NBR).

Spring Loaded Lift Check Valves (25 mm to 400 mm)

A. Spring-loaded lift check valves shall be cast iron body, spring-loaded, center guided disc type with flanged ends Valves shall be designed for a working pressure of 9.0 kg/cm^2, unless specified otherwise elsewhere.

B. The valve shall be suitable to operate in a vertical position with flow upward and shall consist of body, disc, upper guide. disc guide, reverse flow guide disc, spring and by pass valve. Body seat ring shall be bronze casting accurately threaded and screwed into the body. Disc shall have synthetic rubber seat bolted to the disc. Disc, upper guide, disc guide and by pass valve shall be of bronze casting conforming to approved standard Spring shall be of type 304 stainless steel.

8.PLUG VALVES

A. Plug valves shall be of cast iron body, non-lubricated; resilient faced eccentric plug type valves. Valves shall be designed for working pressure 9 kg/cm2, unless specified otherwise elsewhere.

B. Port areas of valves 500 mm and smaller shall be at least 80% of the full pipe area, and it shall be at least 70% for larger valves.

C. The valve body and bonnet shall be of cast iron or ductile iron or a corrosion resistant cast iron alloy containing 1 % to 1.5% nickel. The materials specified above shall have a minimum tensile strength of 2,200 kg/cm^2. If the body is of cast iron, the seat shall have a welded-on overlay of not less than 90% pure nickel on all surfaces contacting the plug face. The seat face shall be machined. If the body is of corrosion resistant cast - iron alloy, the raised seat shall be machine finished and protected with an approved epoxy coating.

D. The plug shall be of cast iron as specified for the body and shall have a resilient coating to provide bubble-tight shutoff. The resilient coating shall be chloroprene (Neoprene). Valves shall be provided with heavy duty pre-lubricated bearings of stainless steel or bronze. Stem seals shall be rubber O-rings or multiple Buna-N packing rings. When packing rings are used, the packing gland and packing shall be accessible without disassembly of the valve.

E. G. All valves, 100 mm in diameter and larger shall be equipped with manual hand wheel operators with worm gear unless otherwise specified. All valves, 80 mm in diameter and smaller shall have a wrench.

9.GLOBE VALVES

General

A. Globe valves shall be as specified hereinafter.

   a. Angle hose valves (10 mm to 100 mm).

   b. Hose bibs (13 mm to 25 mm).

   c. Stainless steel globe valves (15 mm to 300 mm).

B. All valves shall be equipped with cast iron or ductile cast iron hand wheels.

Angle Hose Valves (10 mm to 100 mm)

A. Angle hose valves shall be of bronze body Y-Globe valves with renewable composition discs. Valves shall have rising stem and screwed ends with stainless steel replaceable quick coupling and cap. Working pressure shall be10.0 kg / cm^2 Valves shall be designed and nunlu1actured In accordance with approved standard Screwed Ennis angle valves

B. Discs shall be hard but sufficiently resilient to maintain tight seal within the pressure and temperature range and have high flexural and impact strength discs shall be made of Teflon other materials approved by the engineer.

C. Disc holder shall be made of bronze casting contorting to approved standard or copper conforming to approved standard

Hose Bibs (13 mm to 25 mm)

A. Hose bibs shall be of bronze body globe valves with renewable composition discs Valves shall have rising stems, screw-in bonnet, screwed inlet and hose coupling outlet. Working pressure bonnet, screwed inlet and hose coupling outlet. Working pressure shall be 7.5 kg/crn^2. Valves shall be designed and manufactured in accordance with JIS B2061and shall be of swivel nose faucet, faucet with hose coupling or lawn faucet type.

B. Stem with disc and disc nut shall be bronze, bronze casting or copper. Disc shall be of medium soft composition as recommended by the manufacturer for the intended use.

Stainless Steel Globe Valves (15 mm to 300 mm)

A. Stainless steel globe valves shall be of metal to metal seating type glove valves with outside screw and yoke (OS & Y), rising stems and designed for handling acids. Valves shall have flanged ends and a net flow area not less than the area of a circle with ends and a net flow area not less than the area of a circle with a diameter equal to the nominal pipe size.

B. Unless otherwise specified, major parts of the valve; such as body, bonnet bolts and nuts and other parts which may come in contact with handling liquid shall be made of type 316 stainless steel and stainless steel casting.

10.DIAPHRAGM VALVES

A. Diaphragm valves shall be of the weir of straightway type as noted, with cast iron body, resilient reinforced rubber diaphragm and cast iron bonnet. They shall be fitted for spoke hand wheel operation.

B. The valves shall be designed for use in water, air and weak chemical service lines.

C. The reinforced rubber diaphragm shall be connected to a spindle actuated compressor so that it will be lifted to provide and adequate waterway for minimum pressure loss. Further, the diaphragm shall be forced tight against the body even when the compressor is lowered. The diaphragm shall seal the bonnet compartment and working parts from the fluid stream. The diaphragm shall be capable of ready replacement without removing the valve body form the pipeline.

D. D. The valves shall be protected against corrosion with a minimum 3.0 mm thickness of neoprene lining suitable for the service intended and consistent with associated piping, unless otherwise noted.

11.BALL VALVES

General

A. Ball valves shall be as specified hereinafter.

   a. Stainless steel ball valves for chemical service (15 mm to 350 mm).

   b. Stainless steel ball valves for plant water line (10 mm to 50 mm).

   c. Motorized ball valves (15 mm to 50 mm)

Stainless Steel Ball Valves For chemical Service (15 mm to 350 mm)

A. Stainless steel ball valves shall be of iron lubricated type and .shah have 'feel ball and body with Teflon seals Valves shall be designed for handling chemicals and for working pressures up to10.0 kg/cm^2 Valves shall have flanged ends

B. Valve ports shall have an area at least equal to the area of a circle of diameter equivalent the nominal size of the valve Valves 100 mm and smaller in diameter shall be wrench operated Valves, 125 mm

C. and largo shall be hand wheel operated through a won nit gear. Port position shall he plainly visible to the operator by means of an indicator.

D. Unless otherwise specified, major parts of the valve such as body, stem, ball, gland with gland bolts and nuts. and other parts which may come in contact with handling liquid shall be made of type 316 stainless steel and stainless steel casting.

E. The seats shall be reinforced Teflon and shall be easily replaceable using no special tools. The gland packing shall be of reinforced Teflon and shall be adjustable while the valve is conducting flow and replaceable without removing the valve from the line.

Stainless Steel Ball Valves For Plant Water Line (10 mm to 50 mm)

A. Stainless steel ball valves shall be of non-lubricated type and shall have stainless steel ball and body with Teflon seats. Valves shall be designed for a working pressure of 10.0 kg/cm^2 and shall have screw ends. Valves shall be wrench operated.

B. Major ports of the valve such as body, stem and ball shall be made of type 304 or 306 stainless steel and stainless steel casting.

Motorized Ball Valves (15 mm to 50 mm)

A. Motorized ball valves shall be of non-lubricated type, and shall have stainless steel ball and stainless steel or cast iron body with Teflon scats, and shall have integrated type electric operator. Valves shall be designed plant water line and for working pressure up to 10.0 kg/cm^2. Valves shall have flanged ends.

B. The seats and gland packing shall be reinforced Teflon and stem shall be stainless steel.

A. The electric operator shall be furnished with totally enclosed waterproof construction. Motor shall be of condenser motor type rated at single phase, 200 V and 50 Hz. All electric components shall be designed of solid state electric. The operator shall be designed to provide rotary valve control with one-way rotation direction and to have built in thermal overload protection. Open and close limit switches shall be provided. Port position shall be plainly visible to the operator. The valves shall be designed to operate by wrench.

12.AIR VALVES

General

A. Air valves shall be as specified hereinafter,

   a. Single orifice type air valves (13 mm to 25 mm)

   b. Double orifice type combination) type air valve.-s (50 mm to 150 mm)

B. All air valves mentioned above shall be constructed such that internal working parts, which may become necessary to repair, shall be readily accessible. removable. and replaceable without use of special tools and removing the valve from the line. Typical installation of air valves shall be as shown on the Drawings.

Single Orifice Type Air Valves (13 mm to 25 mm)

A. Single orifice type air valves shall be of cast iron body and single float actuated air valves with flanged ends. Valves shall be designed and manufactured in accordance with approved standard. Working pressure shall be not less than 7.5 kg/cm^2.

B. Valves shall operate automatically so that they will exhaust accumulated air under pressure while the pipe is flowing full of water.

C. Each valve shall be furnished with bronze casting stop valve and cast iron flange, 80 mm in size.

D. Valves shall be applied for pipeline 300 mm in diameter and smaller unless otherwise specified.

Double Orifice and Combination Type Air Valves (50 mm to 150 mm)

A. Double office and combination type air valves shall be cast iron body and double float actuated air valves with flanged ends.

B. Double orifice type air valves shall be designed and manufactured in accordance with approved standard. Working pressure of all air valves shall be at least 7.5 kg/cm^2.

C. Double orifice and combination type valves shall be designed to operate automatically so that they will:

   a. Positively open under internal pressure less than atmospheric pressure to admit air in bulk during pipeline draining operation;

   b. Exhaust air in bulk and positively close as water, under low head, fills the body of the valve during filling operation;

   c. Not blow shut under high velocity air discharge; and

   d. Exhaust accumulated air under pressure while the pipe is flowing full of water.

D. Each double orifice type air valve shall be furnished with a stop valve, the same size as the air valve.

E. Combination type air valves shall be furnished for pipelines 350 mm in diameter and larger unless otherwise specified.

CHAPTER 6

TROLLEY HOISTS

PART-1 GENERAL

1.1 WORK INCLUDED

A. This section of the specifications covers the supply and installation of overhead trolley hoist for handling stop logs to be provided for pumping stations.

B. The supply shall include for each pumping station, but not be limited to, the following main items:

1. One monorail complete with all mechanical, electrical, control and safety equipment.
2. The fixed parts and rails.
3. The steel plates or steel beams to be anchored in the primary concrete, to which will be attached the adjustment rods of the permanent embedded parts.
4. The anchoring and support parts to be embedded in the primary concrete.
5. Special tools and spare parts.
6. Corrosion protection work.
7. Oil and grease for first filling.

1.2 RELATED WORK

A. General requirements.

B. Section 15050 Basic mechanical materials and methods.

C. Section 15080 Mechanical Insulation.

1.2.1 Coordination

A. Work under this section shall be coordinated with work covered by the following sections:

1. Civil Engineering works and Building works.
2. Section 11285 Stop logs.
3. Section 11285 Penstock.
4. Section 11310 Screw pumping station.
5. Division 16 Electrical.

1.3 SYSTEM DESCRIPTION

A. The following represent a proposal for the main hoists characteristics; Contractor is responsible for the required design and subsequent performance

Parameter	Suggested Value
1. Translation speed	10 m/mn
2. Hoisting speed	5 m/mn

B. The overhead trolley hoist shall be designed to handle the stop log located in the inlet sump on the full length of the screw pumping station.

C. The lifting capacity of the hoist shall be able to withstand a possible friction of 1,5 time the weight of one stop log , the lifting beam, the pulley block and lifting cables plus an allowance for possible friction. The lifting capacity shall not be less than 1.5 tons.

D. The coupled hoist shall be electrically driven for both translation and lifting operations.

E. The hoist shall be equipped with a horn to warn of imminent operation.

F. The steel wire rope shall be of sufficient length to reach the stop log sill level.

G. Design Criteria:

1. Refer to Section 15010 Basic mechanical materials and methods.
2. Monorail structure shall be designed as per FEM class A3.
3. Monorail mechanism shall be designed as per FEM class IBm.

1.4 QUALITY ASSURANCE

A. Inspection and tests of raw materials: mechanical tests and chemical analysis certificates shall be delivered by the Manufacturer.

B. Inspection and tests of standard products and cables: routine tests.

C. Workshop inspections and tests :

1. Rails and embedded parts.

   The surface aspect of rails and embedded parts shall be examined and their dimensions checked. Rolling and sliding surfaces shall be perfectly flat and smooth.

2. All dimensions of monorail members shall be checked.
3. The operation of the various motors and mechanisms shall be checked.
4. Welds:

   Refer to Section 15010 Basic mechanical materials and methods

1.5 REFERENCES AND STANDARDS

A. Materials: Refer to Section 15050 Basic mechanical materials and methods

B. Design: Al SC code, FEM rules (1970), ASTM and AF NOR.

C. Welding standard: AFNOR, CODAB OR AQUAP.

1.6 SUBMITTALS

A. Inspection and tests of raw materials: mechanical tests and chemical analysis certificates shall be delivered by the Manufacturer

PART-2 PRODUCTS

2.1 MATERIALS

2.1.1 Monorails Structure

A. The monorail shall consist of a steel section beam of sufficient size to withstand the

combined dynamic load of the coupled pulley blocks with power supply cables, the lifting cables, the gate the lifting beam and any possible frictional forces, plus a 20% safety allowance.

B. The maximum permissible deflection of the monorail beam between its supports shall be 1/800th of the span between two supports.

C. Each end of the monorail shall be fitted with switches and synthetic rubber shock-absorbing buffers.

D. The rail shall be connected to the general grounding network and the joints between beam members shall be electrically bonded.

E. The fixture system of the rail shall be designed in such a manner that its elevation can be adjusted.

2.2 EQUIPMENT

2.2.1 Controls

A. Hoist movement shall be floor controlled on all motions from a non metallic pendart push-button station. This pendant shall be also be equipped with buttons of the hold-on-to-operate type.

B. B. All control relaying equipment shall be installed in a watertight box (IP 55) attached to the monorail hoist unit Refer to Division 16 - Electrical

C. The pendant legends shall be inscribed in both English and Arabic language.

2.2.2 Overload Switches

A. lifting mechanisms shall be equipped with overload switches which shall immediately switch off the hoist motor when the load being lifted exceeds by 20% the rated hoist capacity.

2.2.3 Power Supply to the Monorail Hoists

A. The power supply to the hoist shall be made by means of a 380 V 3 phase 4 wire insulated and enclosed current collected system. Earth conductor shall also be provided. Current collectors will be of spring loaded type with renewable contacts.

B. A weatherproof metalclad load break isolating switch shall be installed at the office side of the monorail and at a height of 1100 mm.

2.2.4 Limit Switches

A. Limit switches shall be provided for all travel motions.

B. Safety limit switches shall be incorporated to prevent accidental over hoisting or over lowering of the hook block.

2.2.5 Special Tools

A. Contractor shall supply the special tools required for monorail maintenance.

PART-3 EXECUTION

3.1 INSPECTION

A. Contractor shall check the setting and alignment of fixed parts as well as the dimensions and setting of the recesses in civil work for embedded parts.

3.2 FIELD QUALITY CONTROL

3.2.1 Rail Track

A. Rail track position shall be checked before and after its definitive setting and clamping.

3.2.2 No Load Test

A. During the testing maneuvers, the following items shall be checked:

1. Correct operation and efficiency of brakes and limit switches.
2. Vertical and horizontal traveling distances and approach measurement.
3. Operating speeds.
4. Operation and characteristics of manual and emergency control.
5. Examination of paint work.
6. Operation of the lifting beam

3.2.3 Commissioning and Acceptance Tests

A. As far as possible, the Contractor shall carry out the load tests under the worst operating conditions in which the hoisting equipment shall be operated under its rated load. In the event of these conditions not being possible, the Contractor shall make provision for the additional loads necessary, in order to be able to simulate the required test conditions :

1. Under the rated load, the same items shall be checked as in the no-load test.
2. In addition, the brakes shall be checked, so as to ensure that they stop the hoisting equipment operating at its rated speed, with a maximum slip of 10 mm and that the load is held in a stationary position without sliding The bearings and other mechanical parts shall also be checked for temperature rise. The temperature of such mechanisms shall not exceed the value specified.
3. Under overload conditions, the overload safety system shall be checked.
4. After completion of the load tests, all suspect components shall be removed and cleaned in order to inspect the bearing surfaces for wear and lack of lubrication. Defective components shall be replaced at the Contractor's expense

B. Testing of complete handling mechanism:

1. Static test

With the handling mechanism in a fixed position, the hoisting equipment shall be tested under an overload 50% greater than its rated load. This load shall be maintained for one hour. The load shall then be relieved gradually. No defect or permanent deformation shall remain after complete removal of the load. This test shall be carried

out at several points of the track.

2. Dynamic test

   a. After satisfactory completion of the static test , the testing load shall be decreased to a value 20% greater than that of the rated of the hoisting equipment. Under these conditions, all the lifting and lowering operations shall be carried out successively for a period of fifteen minutes of effective operation, without vibration, deformation or detrimental temperature rise. Translational movements of the handling mechanism shall be tested under the same conditions as above on the whole length of the track.

   b. During these maneuvers, the following shall be checked :

      - Correct behavior of the handling mechanism along its rolling track: the framework shall remain perpendicular to the track and shall under no circumstances give evidence of any defect or deformation.
      - Correct operation and efficiency of the brakes and limit switches.
      - Adjustment of the starting equipment, adherence of rollers on starting and braking.

   c. After the dynamic tests, the hoist shall be loaded to its rated load and the following shall be checked:

      - The deflection of the beams.
      - The horizontal and vertical travel distances.
      - Correct general operation of the safety mechanisms and accessories.
      - The operating speed
      - The lifting and lowering movements, which shall be made in a continuous smooth manner so that all maneuvers shall be possible with the desired accuracy.
      - Brakes and stopping distance: the hoist brakes shall be capable of stopping the rated load operating at a normal speed with a maximum slip of 10 mm and maintaining this load in a stationary position without slipping.
      - The bearings and other mechanical parts shall also be checked for temperature rise. After the dynamic test, suspect components shall be removed and cleaned in order to inspect the bearing surfaces for wear and lack of lubrication; defective components shall be replaced at the Contractor's expense.
      - Should the Contractor intend to use the overhead trolley for civil works purposes, the Engineer may require a complete refurbishing of the overhead trolley to be undertaken at the Contractor's expense before commissioning.

   d. Examination of paint work.

3.3 SPARE PARTS

A. The Contractor shall supply manufacturers recommended spare parts for two years operation, including the following spare parts:

1. 1 brake lining of each type of brake.
2. 1 set of contacts.
3. 100% of lamps and fuses installed.
4. 1 relay of each type.
5. 20% oil and grease reserve

- END OF SECTION -

CHAPTER 7

BRIDGE CRANES

BRIDGE RUNNING OVERHEAD CRANES

PART-1 GENERAL

1.1 WORK INCLUDED

A. This section covers the supply and installation of overhead traveling crane complete with all mechanical, electrical, control and safety equipment to be provided in the pumping stations The Contractor shall also supply and install the corresponding fixed parts and rails.

1.2 RELATED WORK

A. General requirements.

B. Section 15050 Basic mechanical materials and methods.

C. Division 15 Mechanical/Corrosion protection of mechanical equipment.

1.2.1 Coordination

A. Work under this section shall be coordinated with work covered by the following sections:

1. Civil Engineering works and Building works.
2. Section 11310 Screw pumping station.
3. Division 16 Electrical.

1.3 SYSTEM DESCRIPTION

A. The following represent a proposal for the main hoists characteristics; Contractor is responsible for the required design and subsequent performance.

Parameter	Value
1.Hoisting speeds : Main hook maxi high speed : low speed :	 5.0 m/mn 0.5 m/mn
2.Longitudinal crane traveling speed :	

a.High speed : maximum : b.Low speed:	10 m/mn 0.5 m/mn
3.Transversal trolley speed : a. High speed : maximum : b. Low speed :	 10 m/mn 0.5 m/mn

B. The basic framework and the various mechanisms constituting the crane shall be designed and fabricated to allow all maneuvers of the equipment to be performed smoothly and accurately during erection and maintenance.

C. The combination of movements of the overhead crane and trolley must be such that the hooks can sweep the entire surface area on the full length of the pump motor room and loading bay.

D. The steel wire rope shall be of sufficient length to reach the floor level. Safety limit switches shall be incorporated to prevent accidental over hoisting or over lowering of the hook block.

E. The motor components producing the various movements shall be fitted with a progressively acting braking system which shall operate for any accidental or intentional cutting off of the power supply

F. The crane shall be floor controlled on all motions from a non metallic pendant push button stations.

G. The safe working load shall be clearly marked on a plate in large print in English and Arabic on the cranes, after final installation.

H. Structural members and lifting cable

The structural members and lifting cable and all load-carrying parts are to be constructed of high strength material having the following properties:

1. Minimum ultimate strength :5 times stress at rated load
2. Minimum safety factor : 5 to 1
3. Minimum yield point (2%, offset) :3 times stress at rated load
4. Minimum reduction of area :50 (not applicable for cable)

Endurance limit for parts undergoing cyclic stress is not to be less than the stress at 1.25 times the rated load.

I. Gears

Shall be machined from steel blanks individually forged to give grain refinement in the radial and circumferential direction. Worm gears are to be nickel bronze or the equivalent. Worms are to have a hardened surface on a tough ductile core.

J. Power operated gears

Shall be fully enclosed, provided with dirt and oil seals, and are to run in oil baths.

K. Design Criteria:

1. Unless otherwise specified, the lifting equipment shall be classified to DIN 15020 or FEM (Federation Europeenne de Manutention) as follows :

i. For lifting capacity up to 100 kN (10 tons) "Class 2 m", representing an average daily working time of 2 to 4 hours and an equal share of small, medium and heavy loads (normal duty);

ii. for lifting capacity larger than 100 kN (10 tons) "Class lAm", representing an average daily working time of 2 to 4 hours and a small share of heavy load lifts (light duty).

2. The Contractor shall state the design and calculation standards applied and the factors of safety for the different load combinations and the various equipment components.

3. Every lifting equipment will be subject to a test operation over the entire service area with an overload = 1.25 x nominal load.

4. The crane girders and runway tracks shall be calculated for a deflection not exceeding 1/1000 of the span at maximum nominal load.

5. Steel structures of lifting equipment shall be of welded construction, to be assembled at Site. All field connections and joints shall be bolted.

6. For lubrication, inspection and maintenance, ladders, platforms or stairs shall be provided. All walkways shall have non-slip chequered plate treads and/or non-slip floor grating and shall be equipped with tubular handrails and skirting. Walkways, stairs and platforms for lifting equipment shall be designed generally for a live load of 3000 N/m^2.

7. The material for the fabricated steel structures of lifting equipment shall be weldable structural mild steel to DIN 17100. The use of high strength and fine grain steels require the explicit approval of the Engineer; for these steels the welding specifications described in Clause 5.1.2.9 shall be observed.

8. Allowable stresses for structural parts and connections are stated in DIN 15018.

9. The stresses between the track rails, their fixing elements and the concrete shall not exceed :

i.	Mean compressive stress	7.0	N/mm2
ii.	Compressive stress on edges.	10.0	N/mm2
iii.	Bond stress	0.8	N/mm2

10. Crane mechanisms shall be designed as per FEM class IBm.

1.4 QUALITY ASSURANCE

A. Inspection and tests of raw materials: mechanical tests and chemical analysis certificates delivered by the Contractor.

B. Inspection and tests of standard products and cables : routine tests.

C. Workshop inspections and tests :

1. At the end of manufacture, each assembly or sub-assembly shall be erected and inspected.

i. The surface aspect and fixed parts shall be examined and their dimensions checked. Rolling and sliding surfaces shall be perfectly flat and smooth.

ii. All dimensions of crane members shall be checked.

iii. The operation of the various motors and mechanisms shall be checked.

2. Welds :

i. Refer to Section 15050 Basic mechanical materials and methods.

1.5 REFERENCES AND STANDARDS

A. Generally, for design, stress calculation, manufacture and installation, the following standards and codes, apart from various other relevant standards and regulations, shall be applied:

1. DIN 4100 Welded Steel Structures.
2. DIN 4114 Steel Structures: Stability (pp 1 & 2)
3. DIN 4132 Craneways, Steel Structures, Calculations and Designs.
4. DIN 15018 Cranes, Steel Structures, and Stress Analysis.
5. DIN 15020 Lifting Appliances, Basic principles for Rope Reeving Components, Computation and Design.
6. DIN 15030 Cranes, Acceptance and Testing of Cranes.
7. VBG 8 & 9 (German "Verband der Berufsgenossenschaften"). Accident Prevention for Lifting Equipment and Cranes.
8. VDI 3571 ("Society of German Engineers") rails and Tolerances for Craneways).
9. VDI 3576 ("Societe of German Engineers") Tolerances for Crane Steel Structures.

1.6 SUBMITTALS

A. Inspection and tests of raw materials: mechanical tests and chemical analysis certificates shall be delivered by the Manufacturer

PART-2 PRODUCTS

2.1 MATERIALS

2.1.1 Structure

A. The deflection of the central supporting beam structures under normal design load shall not exceed 1/1000`h of the span.

B. The structure shall be made from welded plate or box girders. All visible parts shall be smooth and perfectly finished. The welds shall be performed so as to give a continuous and smooth finish to the frame.

C. A platform over the full span of the crane shall be provided for the inspection and maintenance of the carriage The footbridges will be made from slip proof sheet metal acid will include hand and foot rails

D. The framework shall be a rigid assembly capable of resisting all horizontal and vertical stresses produced during normal operation rubber bumpers shall be fitted to each end of the crane and trolley and aligned with the buffers on the track .

2.2 EQUIPMENT

2.2.1 General

A. All wheels shall have a hardened tread with a minimum Brinell hardness number of 400, and shall be made of carbon steel or low-alloy steel forgings Bridge and trolley wheels shall have double flanges

B. Flexible couplings shall be installed to relieve the bearings and shafts from any stresses due to misalignment and to facilitate the removal of motors, wheels and gears. The motor couplings also shall be of the flexible type

C. All couplings, drive wheels and gears shall be press fit and keyed to the shaft

D. All bearings preferably shall be roller or ball bearings designed to permit easy shaft disassembly and easy replacement. The minimum average lifetime under design load conditions shall be 5000 hours.

E. For cranes and hoists with a capacity larger than 500 kN, all bearings except those for the hooks and rope block sheaves shall be lubricated by a entrap lubrication system. An independent system for the trolley and one or two independent systems for the bridge will be acceptable. The central lubrication system shall satisfy the following requirements:

1. The lubricant quantity for each bearing shall be variable;
2. Lubricant filters shall be installed in every lubricating pipe.

F. All gear transmission shall be of the oil bath lubricated helical gear type or similar. Low speed spur gears may be lubricated with soft grease. Suitable oil and grease catching drip pans shall be installed and be readily accessible for draining and cleaning.

G. Brakes shall be of the spring-set, electrically (solenoid or electro-hydraulic) released shoe or disc brake. The capacity shall be at least:

1. for bridge and trolley drives 1.5 times
2. for hoist drives 2.0 times

H. The full operating torque of the drive. The run-out time of hoist brakes (time between cut-out of current and complete stop) shall not exceed 0.8 seconds.

I. The brake shall automatically be applied when the motor control switch or the main power switch is in the "off' position and/or when the current fails on any one phase.

J. Nameplates stating the nominal load capacity in kN or tones (as indicated by the Engineer) shall be attached to both sides of the lifting equipment structure and to both sides of the rope block. The printing shall be clearly legible from the floor.

2.2.2 Translation and Direction Mechanism

A. The translation and direction drive gear shall be mounted on the chassis and shall be rigidly installed and well set. Semi-elastic couplings between the motors and the reduction gear

shall be provided. The drive unit shall operate without excessive noise and create no harmful vibrations. The required high speed and low speed shall be obtained by two separate motors. The motors shall be started progressively so as to avoid uneven starting of the overhead crane thereby reducing swinging of the toads to a minimum For the same reasons, the braking system shall also be progressive Provision shall be made for four proximity switch contacts Two of these contacts shall be located so as to slow down the crane before it reaches the end buffers The other two contacts shall enable the crane to be operated at low speed only in the immediate vicinity of the end buffer (an electronic speed variation device is not allowed).

B. The motorized and free rollers shall be interchangeable. The motorized roller driving rim shall be fitted to the rollers by means of adjustable bolts.

C. Provision shall be made for a setting device to be installed near each roller so as to facilitate exchange or repairs if necessary,

2.2.3 Trolley and Hoisting Mechanism

A. The framework of the trolley - hoist shall be a perfectly rigid assembly made from steel plate and metal sections.

B. The drive mechanism and the lifting hoist shall be fitted to the trolley.

C. The motorized rollers shall be fitted with ball or roller bearings. Like the translation gear, the drive-mechanism shall be designed to operate smoothly and without excessive vibration.

D. The hoist drums shall be of the two-way, opposite-groove type enabling the load to be lifted vertically. Provision shall also be made for rope guides. All pulleys shall be fitted with bearings.

E. During lifting, the hook must remain in the same vertical axis and not be subject to any pendular movement. The hoist brakes shall be able to stop the nominal load at the rated slow speed with maximum slip of 4 mm and also maintain the load at rest without any slip. A failure of the motor coupling or gear box shall not cause the load to drop.

F. All movements shall be protected by limit type proximity switches, which shall cut out the power supply to the motor and activate the braking mechanism, thus stopping the motion. In addition to the "high" and "low" limit switches, the hoist shall be fitted with an additional safety limit switch for the high position.

G. The Contractor shall also make provision for special overload devices preventing maneuvers with loads greater than 1.1 times the nominal load. These overload safety devices shall be fitted to the fixed rope attachment points.

H. The Contractor shall also make provision for a device allowing lowering of a load in the event of prolonged power cuts or a motor failure.

I. The brakes must operate in the event of over speed during descent.

2.2.4 Operating Maneuvers

A. Operating maneuvers shall be floor controlled on all motions by the operator from a non metallic pendant push button station. The pendant enclosures shall give protection to IP 54 requirements.

B. Operation of the cranes shall be possible from any position across the full span.

C. The pendant legends shall be inscribed in both English and Arabic language.

2.2.5 Bridge Trucks and Drive

A. Crane

Shall be in the form of double-girder crane with the trolley running on the top. The girders are to be of the box-girder design. The trucks of the crane are generally of welded box-girder construction.

B. Girders

Shall be supported on and rigidly connected to the trucks in such fashion as to assure that the crane remains square on the runway. The girders are to be designed such that deflection does not exceed 1/1000 of the span at the nominal load.

C. Rail sweeps

Shall be provided in front of each wheel, extending below top elevation of runway rails.

D. Safety lugs

Shall be provided to prevent excessive drop from wheel or axle failure.

E. Spring loaded bumpers

Shall be provided at each end of trucks, capable of protecting crane and the building from damage due to hitting the stops at ends of runway. Bumpers are to be mounted so that there is no shear on mounting bolts. Mountings are to be such as to pass shock directly into truck frame. Bumpers are to be mounted so as not to interfere with wheel removal.

F. Truck wheel assembly

Shall be direct drive rotating axle type.

G. Wheel bearing capsules

Shall be provided on either side of each wheel and contain dual tapered roller bearings capable of withstanding radial and thrust loads at rated crane capacity. The bearing capsules are to be mounted in the trucks to produce equal bearing loading and arranged for easy removal by jacking the truck and removing the mounting bolts.

H. Wheels

Shall be designed to operate on standard rails. When more than bridge wheels are used, trucks shall be of the equalizing bogey type.

I. Bridge drive

Shall consist of a motor, hydraulic coupling and gear reducer located at center of span connected by cross - shafts to drive wheels at each end of bridge.

J. Bridge drive system

Shall be equipped with a brake, which shall be capable of stopping the fully loaded crane, at full speed within a distance equal to 10% of the full load speed.

K. Bridge breakers

Shall have a torque rating at least 50% that of the bridge motor.

L. Limit switches

Shall be supplied to control limits of motion, and inching operation.

2.2.6 Trolley

A. Trolley

Shall be overrunning, electrically driven with travel brake with a minimum torque rating equal to 50 % of the trolley motor.

B. Trolley frame

Shall consist of welded steel of rigid construction, designed to transmit the load to the bridge rails without undue deflection.

C. Rail sweeps

Shall be provided for each wheel.

D. Safety lugs

Shall be provided on trolley ends to prevent excessive drop should a wheel or axle fail.

E. Trolley drive

Shall consist of a motor, hydraulic coupling and gear reducer with slow speed shaft to a driving wheel on each side of trolley.

F. Spring loaded trolley stops

Shall be provided at each end of trolley runway.

G. Limit switches

Shall be provided to prevent driving trolley into runway stops and inching operation.

2.2.7 Main and Auxiliary Hoist Units

A. Hoist motors

Shall be sized to have a duty rating adequate to meet the service conditions. The motors shall be capable of developing starting and pull out torque conforming to the standards. The motors shall be foot mounted and have ball or roller bearings and shall have double extended shafts and are to be coupled to the hoist gear cases by flexible couplings.

B. Hoist brake

Shall be equipped with a removable shoe type electrical load brake. The brake shall set automatically when hoist motor power is off. The brake is to have a torque rating confirming to the standards and is to be capable of stopping and holding the rated load with power off.

C. Hoist gear access

Shall be oil tight and contain the gearing required for the hoist drum drives. The case covers shall be easily removable for inspection and maintenance.

D. Limit switches

Shall be equipped with geared (screw type) upper and lower travel limit switches. Hoist is to be provided with a paddle type switch to limit upper travel.

E. Hoist hook

Shall have mechanical latching system to prevent slipping of the wire rope or sling from the hook.

F. Hook and wire rope

Shall have the full rated strength with factor of safety of 5 for safe operation.

G. Hand operated hoist

Shall incorporate a 500 kg hand operated hoist for raising items to the crane walkway for maintenance of the crane.

2.2.8 Platforms

A. Level platform

Shall be provided, along drive girder side, extending full length of girders, to provide access to trolleys, electrical equipment and the lubrication fittings especially arranged for easy access from the platform.

B. Platform

Shall be constructed of 6.4 mm thick checkered plate adequately supported by structural steel securely attached to girders, with handrails and toe plates, conforming to OSHA Standards.

2.2.9 Crane Rails

A. Crane rails

1. Shall confirm to the standards be provided. Standard accessories are to be used for fixing the rails.
2. Shall be directly bonded to the operation hall grounding bus at all ends.

B. Access ladder

Shall be provided on both sides of the building to the crane rails to attend to the crane for maintenance.

2.2.10 2Pendant Control Station

A. Shall be suspended from a trolley mounted on a separate monorail, adjacent to bridge girders, permitting operation from optimum operator positioning.

B. Shall have switches for each crane motion, placed for maximum operator efficiency. Mushroom head emergency-off push button to disconnect the main switch shall also be provided.

2.2.11 Controls

A. Crane

Shall be controlled from operating floor.

B. Control circuits

Shall be 110 volts fed via a control transformer, center tapped to earth on the secondary side.

C. Speed control of hoisting unit

Shall be achieved using slip-ring motors, starting resistor and eddy-current breaks. Hoisting controls are to provide four-stepped speed control.

D. Speed control of traveling and trolley drivers

Shall be achieved using two-speed pole-changing three-phase motors. The traveling and trolley controls are to be two stepped type.

E. Controls

1. Shall be located such they may be serviced from bridge platform.
2. Shall be so designed that all motions shall be rendered safe if any malfunction of operation occurs.

F. Hoist mechanism

Shall include positive means to prevent uncontrolled drop of load in case of loss of power or subsequent return thereof.

G. Protection class

Shall be of all enclosed electrical equipment is to be IP 54.

2.2.12 Electrical Installation

2.2.12.1 General

A. The following shall be installed on the crane.

B. A distribution and general protection switchboard containing the equipment and consisting of the following:

1. General supply breaker fitted with thermal protection relays.
2. A fused single phase transformer to supply the control equipment.
3. A reversing contactor for the drive motors fitted with thermo-magnetic protection relays.
4. The starting contactors.
5. The auxiliary and time delay relays for starting and control.
6. The motor starting resistors housed under air-cooled metal covers.

C. Wiring

1. The Contractor shall provide and install all the necessary wiring between the various items of equipment, the cabinets and the control desk.
2. Whenever possible, the laying and fitting of cables into conduits shall be carried out in the factories so as to reduce on site connection work.

D. Power Supply

1. The main supply line for the overhead crane shall be by means of a 380 V 3 phase 4 wire insulated and enclosed current collected system. Earth conductors shall also be provided. Current collectors shall be of the spring loaded type with renewable contacts. The crane cross conductor system shall be of the festooned cable type, running on rigid support systems.
2. The power supply to the trolleys may be visibly cut by wall switch weather proof (IP 65), lockable in the off position, situated closed to the access ladder, at a height of 1.75 m.
3. Emergency stop mushroom head slap switches shall be mounted in a convenient location.

2.2.13 Installation

A. Lockable isolating switch

Shall be provided on the operation hall wall for isolation and emergency purposes.

B. Cranes

Shall be supplied from a three-phase, four-wire supply and a separate earth conductor.

C. Wheels

Shall not be used for earth connection.

D. Trucks

Shall be supplied via high temperature resistant insulated flexible cables suitable for the ambient temperatures arising at that height.

E. Fixed wiring

Shall be stranded copper conductors, rated at 600 volts and 90 deg. C, with flame-retarding moisture proof heat resistant insulation.

F. Wiring

Shall be installed in metal conduit, except short lengths to collectors, resistors and the like, where flexible conduit may be used.

G. Crane wiring

Shall be compatible, requiring only one external 380 volt connection at the main isolating switch.

H. Socket outlet

Shall be two 16A, three-pin, metal-clad convenience socket outlets are to be provided, one at each end of the bridge.

I. Lead lamp

Shall be suitable for connection to the above socket outlets is to be provided and retained on the bridge for maintenance and emergency purposes. The lead is to be long enough to reach and allow inspection of all parts of the crane structure and mechanism.

PART-3 EXECUTION

3.1 INSPECTION

A. Contractor shall check the setting and alignment of fixed parts as well as the dimensions and setting of the recesses in civil work for embedded parts.

3.2 FIELD QUALITY CONTROL

3.2.1 Rail Track

A. The rail track position shall be checked before and after its definitive setting and clamping.

3.2.2 No Load Test

A. During the testing maneuvers, the following items shall be checked:

1. Correct operation and efficiency of brakes and limit switches.
2. Vertical and horizontal traveling distances and approach measurement.
3. Operating speeds.
4. Operation and characteristics of manual and emergency control.
5. Examination of paint work.
6. Operation of the lifting beam.

3.2.3 Commissioning and Acceptance Tests

A. As far as possible the Contractor shall carry out the load tests under the worst operating conditions in which the hoisting equipment shall be operated under its rated load. In the event of these conditions not being possible, the Contractor shall make provision for the additional loads necessary, in order to be able to simulate the required test conditions:

1. Under the rated load, the same items shall be checked as in the no-load test In addition the brakes shall be checked so as to ensure that they stop the hoisting equipment operating at its rated speed, with a maximum slip of 10 mm, and that the load is held in a stationary position without sliding.
2. The bearings and other mechanical parts shall also be checked for temperature rise. The temperature of such mechanisms shall not exceed the value specified in the supplier's manual.
3. Under overload conditions, the overload safety system shall be checked. After completion of the load tests, all suspect components shall be removed and cleaned in order to inspect the bearing surfaces for wear and lack of lubrication. Defective components shall be replaced at the Contractor's expense.

B. Testing of complete handling mechanism :

1. Static test:

C. With the handling mechanism in a fixed position, the hoisting equipment shall be tested under an overload 50% greater than its rated load. This load shall be maintained for one hour. The load shall then be relieved gradually. No defect or permanent deformation shall remain after complete removal of the load.

1. Dynamic test:

D. After satisfactory completion of the static test, the testing load shall be decreased to a value 20% greater than that of the rated load of the hoisting equipment. Under these conditions, all the lifting and lowering operations shall be carried out successively for a period of fifteen minutes of effective operation, without vibration deformation or detrimental temperature rise. Translational movements of the handling mechanism shall be tested under the same conditions as above.

E. During these maneuvers, the following shall be checked:

1. Correct behavior of the handling mechanism along its rolling track: the framework shall remain perpendicular to the track and shall under no circumstances give evidence of any defect or deformation.
2. Correct operation and efficiency of the brakes and limit switches.
3. Adjustment of the starting equipment, adherence of rollers on starting and braking.

F. After the dynamic tests, the hoist shall be loaded to its rated load and the following shall be checked:

1. Deflection.
2. The horizontal and vertical travel distances.
3. Correct general operation of the safety mechanisms and accessories.
4. Synchronization of pulley operation when several hoists are used.
5. The operating speed.
6. The lifting and lowering movements which shall be made in a continuous smooth manner so that all maneuvers shall be possible with the desired accuracy.
7. Brakes and stopping distance: the hoist brakes shall be capable of stopping the rated load operating at a normal speed with a maximum slip of 10 mm and maintaining this load in a stationary position without slipping.

G. The bearings and other mechanical parts shall also be checked for temperature rise.

H. After the dynamic test, suspect components shall be removed and cleaned in order to inspect the bearing surfaces for wear and lack of lubrication; defective components shall be replaced at the Contractor's expense before commissioning.

3.3 SPARE PARTS

A. The Contractor shall supply manufacturers recommended spare parts for two years operation, including the following spare parts:

1. Brake coil of each type.
2. One set of brake shoes with lining in place for each size and type of brake supplied.
3. Two sets of three suspension clips with insulators.
4. One set of flexible straight and ring connections of each type.
5. A spare coil and one set of contacts for each contactor supplied.
6. 20% oil and grease reserve.
7. 100% of fuses, signal and lighting lamps supplied.
8. One spare of each relay, pushbutton and limit switch supplied.

- END OF SECTION -

CHAPTER 8

SCREENING AND GRINDING EQUIPMENT

PART-1 GENERAL

1.1 WORK INCLUDED

A. This section includes the manufacture. delivery, installation, testing, commissioning, guarantee and maintenance of screening and grinding equipment complete with all accessories and spares as specified in the following clauses.

B. These specifications shall cover the whole of the screening and grinding equipment, which shall be of first class manufacture and in every way suitable for wastewater works and shall be supplied generally in accordance with the intent of the specification.

C. The contractor shall provide all labor, materials, equipment and incidentals to furnish and install the complete screening and grinding works as specified herein,

D. The Contractor shall be responsible for testing and placing the complete technical work in satisfactory operation to the approval of the Engineer.

1.2 SYSTEM DESCRIPTION

A. The system requirements shall include mechanical (as per contractor design)/fine screens as the permanent screening facility.

B. In cases were mechanical/fine screens fail due to any fault condition, manual screens shall be operated.

C. The following items shall be provided for the screening chamber:

1. Straight bar screen with crab cleaning devices, complete with all necessary accessories.
2. Belt conveyor.
3. Manual screens.
4. Isolating gates
5. Drum trucks for screening moving to disposal.
6. Grinders

1.3 SPARE PARTS AND TOOLS

A. The tenderer shall supply spare parts and tools for all the machinery and equipment offered which he recommends as being necessary for maintenance purposes for 2 years and with the due regard for local conditions and the availability of such spares.

B. Spares shall include the following as minimum requirements:

1. Electric motor complete with electric break for each screen.
2. A complete set of air contractor for each screen and for the belt conveyor.

3. Set of all relays in the control cabinet for all screens and the belt conveyor.
4. All bearings for each screen (if any).
5. Racking arms.
6. All limit switches for all screens.

PART-2 PRODUCTS

2.1 MECHANICAL SCREENS

A. The screen shall meet the following requirements

1. Abnormal amount of screenings to be removed gradually without overloading or damaging the screen bars or mechanism.
2. Clear span between bats as per design criteria
3. The screen bars racking mechanism and control equipment should be completely reliable, robust, rigid and having minimum vibration during operation,
4. The type of screen shall be rack-and-pinion bar screen. Suitable for inclined installation.

2.1.1 Frame

A. The frame shall be constructed from either steel section "U" channel or cold bent sheet steel. Sliding rails for rack hinges as well as chain guides shall all be fitted in the frame. Motor drive is housed on an emerging head on top of frame.

2.1.2 Raking Mechanism

A. The rake is formed of several parts of slotted sheet steel plates having adequate length and section. The slotted sheet steel plates are bolted to common base section which is carried by two arms of strong structural steel. The two arms are secured on top to raking levers.

B. The translation of rack is achieved by means of two long-pitched link chains (other approved type can be accepted). These are driven by two couples of pinions in such a way kept always outside the water. Transmission of motion from chains to screening rack is effected through the racking levers.

C. Electric motor, induction type, fan cooled totally closed, weather protected and having ample power to be used to drive the racking mechanism.

2.1.3 Bar Screen

A. The bars shall be formed of heavy section steel bars. The bar section is rectangular in shape fitted along water stream in the sense providing the maximum moment of inertia to prevent bending. The spacing between each two adjacent bars shall be 25 mm. and bar length will be 1 (one) m. approx.

2.1.4 Bearings

A. The bearings and all rotating parts to be above liquid level at all times. They should need minimum maintenance, reliable and trouble-free. They shall be grease lubricated using simple arrangement for application.

2.1.5 Control Cabinet

A. Outdoor, weather-proof, provided with air break contactors (with short circuit and over load protection). Complete with selector switches for automatic and manual operation of the screen motor. Automatic operation of the screen motor shall be effected through a differential level control using bubbling system. All parts of rack assembly shall remain above the liquid level at the end of each cleaning cycle.

2.1.6 Belt Conveyor

A. Screening collected from each individual screen shall be discharged on a common belt conveyor.

B. The conveyor bed (belt) shall be made of special durable synthetic rubber suitable for strong sewage applications and type of screening collected.

C. The conveyor width shall suit the amount of screening and shall be guided and laid over stainless steel rollers spaced at convenient distances.

D. The conveyor shall carry the screenings to the dropping shut.

E. The cross movement of the belt shall be electric and effected automatically following the operation of any screening unit.

F. It shall also automatically come into rest after expiration of a time delay period following stoppage of the last screening unit.

G. Manual operation of the belt conveyer should be possible to over ride faulty automatic controller and to serve the manual screening assembly.

2.2 MANUAL SCREENS

A. The screen bars shall be formed from strong straight steel bars.

B. The bar section shall be heavy rectangular in shape and the bar fixed in the coarse of water stream in the sense providing the maximum bending moment to prevent bending by the accumulated screening as pushed by the water.

C. The clear space between each two adjacent bars shall be 50 mm.

D. The bars shall be supplied completely assembled inside a common frame of heavy steel sections, and suitable for inclined installation at 45 to 70 degrees to the horizontal.

E. This item of works include the supply of 6 No. light aluminum manual racking devices.

2.3 GRIT WASHER

2.3.1 General

A. Type: Air bubbling screw conveyor type.

B. Operation: Automatic and Manual.

C. Electric Motor: 3 phase, 380V, 50 Hz.

D. Washing Water Inlet: not less than 50 mm by spray pump.

E. Washing Water Outlet: 80 mm drain to nearest pit.

2.3.2 Materials

A. The conveyor the washing parts shall be fabricated from stainless steel or an approved equivalent.

2.3.3 Accessories

A. Manufacturer recommended accessories, yet including but not limited to:

1. Sand container
2. Solenoid valves
3. Piping system

2.4 SAND CYCLONE

1. The capacity of the cyclone shall be defined by Contractor.
2. It shall be fabricated of aluminum or approved equivalent.

2.5 DRUM TRUCKS

A. The contract shall include drum trucks for handling of screenings in standard capacity it shall be of all steel welded construction complete with automatic safety locks

B. Saddle for drum shall be included .

- END OF SECTION -

CHAPTER 9

FANS

PART-1 GENERAL

1.1 WORK INCLUDED

A. Provide All labor materials equipment and incidentals necessary to furnish and install the ventilating systems complete as specified herein. The work in chides all supply air fans except those supplying conditioned (cooked) air all exhaust fans all ductwork connected with the supply and exhaust fans louvers hangers electric wiring and supports

B. The type of fans shall be as specified hereinafter and the fans shall be complete with electric motor louver or automatic louver where specified and all other necessary appurtenances.

1. Propeller fans.
2. Roof fans.

C. These specifications only indicate the extent and general arrangement of the ventilating systems. The Contractor shall be responsible for design furnishing and installing the proposed systems as indicated without violation of specification requirements.

D. Equipment and duct work arrangements shall fit into the spaces and shall allow adequate and approved clearances for entry, servicing and maintenance.

1.2 SUBMITTALS

A. Literature and shop drawings, describing each item of equipment shall be submitted to the Engineer for approval.

B. The literature and shop drawings shall include sufficient descriptive materials such as catalogs, cuts diagrams and other data published by the manufacture to demonstrate conformance with requirements of the Contract Documents.

1.3 IDENTIFICATION

A. Each major item of equipment and materials shall be not less than those indicated.

1.4 SAFETY REQUIREMENTS

A. Belts, pulleys, chains, gears, couplings, projecting set-screws, keys and other rotating parts located so that personnel can come in closed proximity thereto shall be fully enclosed or properly guarded.

PART-2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

2.1.1 General

A. Materials and equipment shall conform to the requirements specified herein and as shown

on the Drawings, and shall be the products of manufactures regularly engaged in the manufacture of such products. Items of equipment shall essentially duplicate equipment that has been in satisfactory use at least five (5) years. Where more than one unit of same capacity is required they shall be of the same model with all parts interchangeable.

2.1.2 Motors

A. Unless otherwise specified motors shall be of totally enclosed fan cooled type.

2.1.3 Propeller Fans

A. Propeller fans stroll he shall be of exhaust type for high-pressure industrial use.

B. Fans shall be of three blade type and blades shall be designed to ensure low noise high volume of airflow and high efficiency .

C. Fans shall be directly coupled with motor and fan and heavy metal frames shall support motor assembly.

D. Fans shall be fabricated from steel sheets conforming to approved standard or aluminum alloy sheets conforming to approved standard. Frame shall be fabricated from steel sheets specified above. When anti-acid type will be specified in the Technical Specification, fan, frame shaft bolts and nuts and other parts shall be of type 304 stainless steel.

E. Unless otherwise specified automatic louvers shall be provided with all propeller fans. An automatic louver shall be gravity shutters and shall be factory fabricated of parallel-blade type with delicately balanced blades that open automatically when the fan starts and close by gravity when fan stops. The louver blades shall be fabricated from aluminum sheets. The edges of the blades shall be provided with felt or rubber strips to prevent rattling. Louver blades shall be supported on aluminum frames and shall be connected to a vertical bar so all blades open equally.

F. When specified in the Technical Specification, fixed louvers of outdoor rain hoods shall be provided. Fixed louvers shall be parallel-blade type and fabricated from aluminum sheets. Outdoor rain hoods shall be of type 304 stainless steel and shall have sufficient opening area.

G. Automatic louvers, fixed louvers and outdoor rain hoods shall be supplied by the same manufacturer as that of fans unless otherwise specified.

H. Equipment and component items when fabricated from ferrous metal they shall be factory finished with epoxy resin paint of manufacturers standard.

I. Factory performance tests for the specified propeller fans shall be executed in accordance with approved standards by the Engineer.

2.1.4 Roof Fans

A. Roof fans shall be specially designed for installation on building roof and be exhaust type unless otherwise specified.

B. Roof fans shall consist of body frame, guard net fan motor unit and top hood. The body frame and top hood shall be hinged, swing open type for easy maintenance and shall have reverse flow prevention flaps and anti-resonant vibration foot.

C. Fans shall be designed to have deeply twisted blades and to ensure high volume airflow at

high static pressure and high efficiency. Fans shall be directly coupled with their motor and fan and motor assembly shall be supported by a heavy metal support unit. Fan motor unit shall be bolted to the body frame and shall be designed to be easily dismantle from the body frame.

D. The body frame and top hood shall be fabricated from steel sheets conforming to approved standard. Minimum thickness of the steel sheet for the body frame and the top hood shall be 1.6 mm and 1.2 mm, respectively. Fan shall be fabricated from steel sheets as specified above or of aluminum alloy sheets conforming to approved standard.

E. Equipment and component items, when fabricated from ferrous metal shall be finished with epoxy resin paint of manufacturers standard or hot-dipped galvanizing except that parts exposed outside shall have shop coats of "Paint System A" alkyd resin paint system as specified in the TECHNICAL SPECIFICATIONS.

2.2 TESTS

2.2.1 Factory Performance Tests

A. A. Unless otherwise specified all fans shall be tested at the manutacture's plant to demonstrate complete with these specifications Six (6) copies of test data including flow and pressure characteristic curve. required power, current and others shall be submitted for approval prior to shipment..

2.2.2 Field Tests

A. Upon completion and prior to acceptance of the installation the Contractor shall subject the ventilating systems to such operating tests as may be required by the Engineer to demonstrate satisfactory functional and operating efficiency. Operating tests shall cover a period of not less than six (6) hours for each system and all tests shall be conducted at such times as the Engineer may direct.

B. If tests do not demonstrate satisfactory operation of the ventilating systems, deficiencies shall be corrected and the system retested. All instrument facilities and labor required to properly conduct the tests shall be provided by the contractor.

- END OF SECTION -

DIVISION 100 – ELECTRICAL

SECTION 1000- BASIC ELECTRICAL MATERIALS AND METHODS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Conditions of Contract and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:

1. General provisions applicable to Division 16 work and other Sections of the Specification that refer to this Section.
2. Supporting devices for electrical components.
3. Electrical identification.
4. Covers, brackets and supports.
5. Electricity-metering components.
6. Concrete equipment bases.
7. Electrical demolition.
8. Cutting and patching for electrical construction.
9. Touchup painting.

B. Electrical Work, unless otherwise specified, includes the supply, installation, testing and commissioning of the complete electrical systems, equipment and materials shown on the Drawings and/or described in the Specification together with all associated ancillary work, support work and builder's work in connection.

1.3 REGULATIONS AND STANDARDS

A. Regulations: Carry out electrical work in accordance with the current issue of the local codes of practice, local power authority regulations and Requirements for Electrical Installations – IEE Wiring Regulations (BS 7671) as published by the Institution of Electrical Engineers and National Electrical Code (NEC / NFPA 70) as published by the National Fire Protection Association where not in contradiction with the local codes of practice and regulations, herein referred to collectively as 'the Regulations'.

B. Conflict: Should an instance occur in this Specification or on the Drawings in which material or construction methods called for is less than minimum requirement of the Regulations, immediately inform the Engineer in writing. Consequent to Engineer's approval, supply the materials and perform the work as though called for to minimum code standards.

C. Standards: Unless otherwise specified, equipment and materials are to be manufactured and installed in compliance with the relevant recommendations of the following or other equal and approved standards:

1. IEC: The International Electro-technical Commission

2. ISO: The International Standardization Organization
3. CCITT: The International Telephone and Telegraph Consultative Committee
4. Lightning protection code of practice (BS6651)
5. ANSI: American National standard institute
6. NEMA: National Electrical Manufacturer Association
7. UL: Underwriters laboratories.
8. European norms EN81-1 for lifts.

D. Local standards, where enforced and relevant, are to have precedence over the Standards.

1.4 POWER SUPPLY

A. The Local Power Authority will provide incoming power supply and connection at 22 kV to the ring main units located in the Authority dedicated room as shown on drawings..

B. Power Supply: Liaise with the Local Power Authority to confirm:

1. Characteristics of supply and system earthing.
2. Location of incoming supply shown on the Drawings.
3. Space requirements and associated builder's work for the Authority's installations.
4. Make necessary arrangements at the earliest opportunity to ensure connection as and when required, and inform the Engineer in the event of any foreseen delay.

C. KWH-metering: Liaise with the Local Power Authority and provide necessary instrumentation, enclosures and accessories required by them to effect a complete kWH-metering installation.

D. KWH-metering will be at Medium voltage side as shown on the Drawings.

E. Nominal characteristics of power supply and distribution are as follows:

1. Medium voltage: 22 kV, 3 phases, 3 wire impedance earthed neutral.
2. Low voltage: 380/220 V, 3 phases, 4 wire, solidly earthed neutral.
3. Frequency: 50 Hz.

F. Distribution systems are to be supplied or derived from the voltage system previously described, as shown on the Drawings, or as otherwise specified.

1.5 TELEPHONE PUBLIC EXCHANGE LINES

A. The Local Telephone Authority will bring telephone public exchange lines into the premises to the location shown on the Drawings and/or to be agreed with the Authority. Liaise with the Local Telephone Authority to confirm location of connection of public telephone exchange lines into the premises.

1.6 EQUIPMENT

A. Equipment Spaces and Rooms: Verify that dimensions, structure, ventilating and cooling arrangements and other provisions in equipment spaces and rooms are suitable for installation, operation and maintenance of proposed equipment. Note any discrepancies on the shop and construction drawings.

B. Equipment is to be designed for the system voltage and frequency previously described, unless otherwise specified. Special provisions are to be made for equipment sensitive to power supply frequency and voltage variations and for equipment operated at other voltages/frequencies or by direct current sources.

1.7 CLIMATIC CONDITIONS

A. Equipment, including transformers, switchgear, cables, relays, lighting fixtures, motors etc., is to be designed and derated for continuous and trouble free service under the following climatic conditions:

1. Altitude: 500 m above sea level.
2. Maximum ambient temperature: 50 degrees C (in the shade).
3. Minimum ambient temperature: 0 degrees C.
4. Maximum relative humidity: 18.3 %.

B. Where design and operating conditions, different from the above are required for particular equipment, they are described in the specification of the equipment concerned.

1.8 DRAWINGS

A. Equipment locations shown on the Drawings indicate approximate locations and general layout of equipment. Exact and final locations and layouts together with dimensions, weights, mounting methods and accessories, where relevant, are to be shown on Contractor's shop and construction drawings.

B. Symbols: In order to provide sufficient detail and a minimum degree of clarity on the Drawings, the symbols used for various electrical devices, particularly wall mounted devices, take up more space on the Drawings than the device does on the wall. Because of drafting limitations these locations must be considered as being indicative rather than exact physical locations of the devices. The devices shall be installed with prime regard for convenience of operation and the proper usage of the wall space rather than to coincide with the scaled locations of the symbols. In locating the outlets, follow the criteria provided on detail Drawings where provided, and coordinate with furniture. Do not scale from design Drawings.

C. Wiring layouts shown on the Drawings are to be used as a guide only to defining basic positions, circuiting, loading and switching arrangements. Actual layouts and details of routing of circuits are to be shown on the Contractor's shop and construction drawings.

D. Wiring layouts shown on the Drawings for work not included in the Electrical Work, such as motor control centres/panels, cables to motors and other similar electrically operated equipment are shown for convenience and reference only.

1.9 SUBMITTALS

A. Generally: Submit for approval, manufacturers' technical literature, shop and construction drawings and other information required by the Specification, before ordering equipment or materials and before executing any related work on site.

B. Product Data: For electricity-metering equipment, covers and supports.

C. Shop and Construction Drawings:

1. Dimensioned plans and sections or elevation layouts of electricity-metering equipment.
2. Shop and construction drawings must demonstrate that the design requirements are understood by indicating all equipment and material proposed to be supplied and installed and by detailing fabrication and installation methods proposed to be used. Shop and construction drawings are to clearly state the name and location of the work, the names of Engineer and Contractor, submission date, cross-references to the Drawings and Specification and the specific reference number, location, service and function of each item.
3. Shop and construction drawings are to be submitted at a scale of 1:50 for general layout plans, and 1:10, or 1:20 as approved by the Engineer for sections, details, elevations, congested layouts, etc. Drawings shall include but not be limited to the following:

    a. Details of electrical installations in conjunction with all trades concerned, showing sleeves and openings for passage through floor structure.
    b. Composite construction drawings fully dimensioned, in metric, showing locations of cables, conduits, bus ducts, shafts, mechanical and electrical equipment rooms, ceiling spaces and all other critical locations
    c. Plans showing equipment layouts including all details pertaining to clearances, access, sleeves, electrical connections, location and elevation of pipes, ducts, conduits, etc.
    d. Plans, sections and elevations of electrical spaces to illustrate compliance with Standards for allocation of spaces for maintenance, movement, installation, etc.

D. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.

E. Coordination Study: Carry out a short circuit and protection coordination study, for the electrical distribution network, and submitted to Engineer for approval.

F. Technical Literature: Include detailed manufacturers' specifications and original catalogues or catalogue cuts, characteristics, model number, application and operating criteria of all equipment and materials, together with other information necessary to satisfy Engineer that proposed equipment and systems are suitable and adequate.

G. List of Proposed Manufacturers: Of all equipment and materials, including all items for which choice of manufacturer is at own discretion, is to be submitted for approval.

H. Assembled Equipment: Any assembled equipment to be supplied for the project is to be assembled by the manufacturer or his authorized assembler. Submit the necessary documents to substantiate the above including the assembler staff training, quality control, etc. The Engineer reserves the right to reject any local assembler if the information submitted is not sufficient. The Engineer's rejection in that respect is final and not subject to discussion.

I. Test Certificates and Reports: Submit manufacturer's type and routine test certificates and reports for equipment and devices. Complete test results are to be submitted in clearly identified and organised

booklets, indicating item of equipment, make, model, type, date of tests, type of tests, descriptions and procedures. Include in the test reports the Quality Assurance Certification, the standards to which the equipment comply, and the standards to which the equipment was tested.

J. Factory Testing: Locally manufactured/assembled equipment is to comply with the relevant standards recommendations and are to be witnessed by Engineer. If the manufacturer's test certificates/tests are not complying with the standards, then independent laboratory tests are to be carried out on equipment in accordance with the Specification and the Standards, and as required by Engineer. The Engineer's requirements in that respect are final and not subject to discussion.

K. Spare Parts Schedules: Submit with the Tender itemised schedules of spare parts to be provided, as required by the Specification, and state against each item the manufacturer's unit price including packaging and delivery to site.

L. Tools and Instruments Schedules: Submit with the Tender itemised schedules of tools and instruments to be provided, as required by the Specification, and state against each item the manufacturer's unit price including packaging and delivery to site.

M. Labeling Schedule: Submit for approval, prior to installation, a schedule of all equipment and devices to be labeled and the suggested details, lettering, position and fixing methods of each label indicating its application.

N. Samples: Submit samples of all equipment and materials for approval. Major items of equipment for which samples cannot be submitted are to be demonstrated in existing installations or by manufacturer's information, test certificates and reports.

1.10 QUALITY ASSURANCE

A. Comply with related Standards, specified there in.

B. Installations are to be carried out by qualified personnel.

1.11 COORDINATION

A. Coordinate chases, slots, inserts, sleeves, and openings with general construction work and arrange in building structure during progress of construction to facilitate the electrical installations that follow.

1. Set inserts and sleeves in poured-in-place concrete, masonry work, and other structural components as they are constructed.

B. Sequence, coordinate, and integrate installing electrical materials and equipment for efficient flow of the Work. Coordinate installing large equipment requiring positioning before closing in the building.

C. Coordinate electrical service connections to components furnished by utility companies.

1. Coordinate installation and connection of exterior underground and overhead utilities and services, including provision for electricity-metering components.

2. Comply with requirements of authorities having jurisdiction and of utility company providing electrical power and other services.

D. Coordinate location of access panels and doors for electrical items that are concealed by finished surfaces. Access doors and panels are specified in Division 8 Section "Access Doors."

E. Where electrical identification devices are applied to field-finished surfaces, coordinate installation of identification devices with completion of finished surface.

F. Where acoustical ceilings and similar finishes will conceal electrical identification markings and devices, coordinate installation of these items before ceiling installation.

1.12 EQUIPMENT AND MATERIALS

A. Availability: Confirm availability of equipment and materials proposed for use in the work prior to submission for approval. If, after approval, equipment or materials cease to be available, submit alternative items of equal quality and type for approval.

B. Acceptance by Authority: Confirm that proposed equipment and material characteristics where required are compatible with the requirements of the Local Power Authority or other Authorities having jurisdiction and are acceptable to them. Inform Engineer of any modifications necessary to comply with the Local Power Authority's requirements.

C. Manufacturers' Standards: Equipment is to be the latest standard product of the manufacturer. Component parts are to be the product of a single manufacturer, unless otherwise approved and provided that components made by other manufacturers are of a standard design and are interchangeable.

D. Approved Manufacturers: Listing of approved manufacturers in the Specification does not necessarily constitute approval of their standard products as equal to those specified. Ascertain that listed manufacturers are able to supply equipment and material in conformity with the Specification.

E. Factory Assembly: Equipment generally is to be supplied in complete factory assembled units ready for installation on site. Dis-assembly necessary for transportation or other purposes is to be arranged to limit site work to simple re- assembly and inter-wiring of control and power cabling.

F. Storage of Materials: Equipment and materials are to be stored in an approved location, under cover, free from humidity, dust, debris and rodents. Equipment sensitive to heat and humidity is to be kept in climatically conditioned areas until installed and handed over.

G. Defective Equipment: The Employer reserves the right to operate operable defective equipment during the Defects Liability Period until it can be removed from service for repair or replacement.

H. Warranty: Where required by the Specification, provide a warranty, signed by the manufacturer (including his agreement to replace promptly, defective equipment or parts thereof, as instructed by the Engineer)

covering materials and workmanship for the period stated in the Specification, starting at substantial completion. Assign the benefits of such warranty to the Employer.

I. Spare Parts: Not later than the date of substantial completion, provide spare parts required by the Specification, together with suitable means of identifying, storing and securing same.

J. Tools and Instruments: Not later than the date of substantial completion, provide sets of tools and instruments required by the Specification, together with suitable means of identifying, storing and securing same.

K. Label and identify all equipment, instruments, control and electrical devices etc. to indicate duty, service or function, to the satisfaction of Engineer. Labels are to be in English and Arabic. Alternative methods of labelling may be submitted for approval. Fix labels with non-corrodible screws to equipment, or to adjacent permanent surfaces or as approved by Engineer.

L. Systems used before substantial completion are to have all consumable elements, such as lamps etc. and defective equipment replaced by new, within 7 days prior to the date of substantial completion.

PART 2 - PRODUCTS

2.1 SUPPORTING DEVICES

A. Material: Cold-formed steel, with corrosion-resistant coating.

B. Metal Items for Use Outdoors or in Damp Locations: Hot-dip galvanized steel.

C. Slotted-Steel Channel Supports: Flange edges turned toward web, and 14-mm diameter slotted holes at a maximum of 50-mm centers in webs.

1. Channel Thickness: Selected to suit structural loading.
2. Fittings and Accessories: Products of the same manufacturer as channel supports.

D. Nonmetallic Channel and Angle Systems: Structural-grade, factory-formed, glass-fiber-resin channels and angles with 14-mm diameter holes at a maximum of 200-mm centers in at least one surface.

1. Fittings and Accessories: Products of the same manufacturer as channels and angles.
2. Fittings and Accessory Materials: Same as channels and angles, except metal items may be stainless steel.

E. Raceway and Cable Supports: Manufactured clevis hangers, riser clamps, straps, threaded C-clamps with retainers, ceiling trapeze hangers, wall brackets, and spring-steel clamps or click-type hangers.

F. Pipe Sleeves: Rigid heavy gauge PVC conduits..

G. Cable Supports for Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug for non-armored electrical cables in riser conduits. Plugs have number and size

of conductor gripping holes as required to suit individual risers. Body constructed of malleable-iron casting with hot-dip galvanized finish.

H. Expansion Anchors: Carbon-steel wedge or sleeve type.

I. Toggle Bolts: All-steel springhead type.

2.2 ELECTRICAL IDENTIFICATION

A. Identification Devices: A single type of identification product for each application category. Use colors prescribed by these Specifications.

B. Raceway and Cable Labels: Minimum size of letters for legend and minimum length of color field for each raceway and cable size to meet Standards.

1. Type: Pre-tensioned, wraparound plastic sleeves. Flexible, preprinted, color-coded, acrylic band sized to suit the diameter of the item it identifies.
2. Type: Pre-printed, flexible, self-adhesive, vinyl. Legend is over-laminated with a clear, weather- and chemical-resistant coating.
3. Color: Black letters on orange background.
4. Legend: Indicates voltage.

C. Colored Adhesive Marking Tape for Raceways, Wires, and Cables: Self-adhesive vinyl tape, not less than 25 mm wide by 0.08 mm thick.

D. Underground Warning Tape: Permanent, bright-colored, continuous-printed, vinyl tape with the following features:

1. Not less than 150 mm wide by 0.102 mm thick.
2. Compounded for permanent direct-burial service.
3. Embedded continuous metallic strip or core.
4. Printed legend that indicates type of underground line.

E. Tape Markers for Wire: Vinyl or vinyl-cloth, self-adhesive, wraparound type with preprinted numbers and letters.

F. Equipment Nameplates: Non-corroding, robust metal, inscribed in English, and firmly fixed to equipment at factory. Nameplates are to indicate name and address of manufacturer, model, serial number, basic characteristics and ratings of equipment and are to include elementary diagrams etc., all in accordance with the Standards.

G. Color-Coding Cable Ties: Nylon, self-locking type. Colors to suit coding scheme.

H. Engraved-Plastic Labels, Signs, and Instruction Plates: Engraving stock, melamine plastic laminate punched or drilled for mechanical fasteners 1.6-mm minimum thickness for signs up to 129 sq. cm and 3.2-mm minimum thickness for larger sizes. Engraved legend in black letters on white background.

I. Interior Warning and Caution Signs: Preprinted, aluminum, baked-enamel-finish signs, punched or drilled for mechanical fasteners, with colors, legend, and size appropriate to the application.

J. Exterior Warning and Caution Signs: Weather-resistant, non-fading, preprinted, cellulose-acetate butyrate signs with 1-mm, galvanized-steel backing, with colors, legend, and size appropriate to the application. 6-mm grommets in corners for mounting.

K. Fasteners for Nameplates and Signs: Self-tapping, stainless steel screws or No. 10/32 stainless-steel machine screws with nuts and flat and lock washers.

2.3 COVERS FOR TRENCHES

A. Covers in electrical rooms and the like, unless otherwise specified or shown on the Drawings, are to be flanged checkered steel plates with angle or channel- section frames, suitably reinforced to support anticipated loads, and finished with zinc chromate primer and two coats gray enamel.

2.4 BRACKETS, SUPPORTS, RAILS AND TRACKS

A. Brackets, supports, rails and tracks for supporting electrical installations are to be galvanized steel, fixed with expansion bolts of approved size and material. Plastic inserts and lead anchors are not acceptable unless approved for specific light duty installations.

2.5 CONCRETE BASES

A. Equipment Foundations and Bases: Reinforced concrete, as approved by Engineer after submission of design calculations. Dimensions, levels and surface finishes are to be suitable for equipment installed, as shown on the Drawings or in accordance with approved shop and construction drawings.

2.6 TOUCHUP PAINT

A. For Equipment: Equipment manufacturer's paint selected to match installed equipment finish.

B. Galvanized Surfaces: Zinc-rich paint recommended by item manufacturer.

PART 3 - EXECUTION

3.1 ELECTRICAL EQUIPMENT INSTALLATION

A. Installations Generally:

1. Carry out Electrical Work in accordance with the Drawings, Specification and Regulations, ensuring compliance with design and performance requirements, to provide safe and protected systems with equipment readily accessible for operation, maintenance and repair.

2. Installations are to be completed, ready for operation and fully integrated and coordinated with all other work.
3. Provide accessories necessary to complete the installations, of the types specified or recommended for the purpose by the manufacturer of the equipment or accessories.

B. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide the maximum possible headroom.

C. Materials and Components: Install level, plumb, and parallel and perpendicular to other building systems and components, unless otherwise indicated.

D. Equipment: Install to facilitate service, maintenance, and repair or replacement of components. Connect for ease of disconnecting, with minimum interference with other installations.

E. Right of Way: Give to raceways and piping systems installed at a required slope.

3.2 ELECTRICAL SUPPORTING DEVICE APPLICATION

A. Damp Locations and Outdoors: Hot-dip galvanized materials or nonmetallic, U-channel system components.

B. Dry Locations: Steel materials.

C. Support Clamps for PVC Raceways: Click-type clamp system.

D. Selection of Supports: Comply with manufacturer's written instructions.

E. Strength of Supports: Adequate to carry present and future loads, times a safety factor of at least four; minimum of 90-kg design load.

3.3 SUPPORT INSTALLATION

A. Install support devices to securely and permanently fasten and support electrical components.

B. Install individual and multiple raceway hangers and riser clamps to support raceways. Provide U-bolts, clamps, attachments and other hardware necessary for hanger assemblies and for securing hanger rods and conduits.

C. Support parallel runs of horizontal raceways together on trapeze- or bracket-type hangers.

D. Size supports for multiple raceway installations so capacity can be increased by a 25 percent minimum in the future.

E. Support individual horizontal raceways with separate, malleable-iron pipe hangers or clamps.

F. Install 6-mm- diameter or larger threaded steel hanger rods, unless otherwise indicated.

G. Arrange supports in vertical runs so the weight of raceways and enclosed conductors is carried entirely by raceway supports, with no weight load on raceway terminals.

H. Simultaneously install vertical conductor supports with conductors.

I. Separately support cast boxes that are threaded to raceways and used for fixture support. Support sheet-metal boxes directly from the building structure or by bar hangers. If bar hangers are used, attach bar to raceways on opposite sides of the box and support the raceway with an approved fastener not more than 600 mm from the box.

J. Install metal channel racks for mounting cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices unless components are mounted directly to structural elements of adequate strength.

K. Install sleeves for cable and raceway penetrations of concrete slabs and walls unless core-drilled holes are used. Install sleeves for cable and raceway penetrations of masonry and fire-rated gypsum walls and of all other fire-rated floor and wall assemblies. Install sleeves during erection of concrete and masonry walls.

L. Securely fasten electrical items and their supports to the building structure, unless otherwise indicated. Perform fastening according to the following unless other fastening methods are indicated:

1. Wood: Fasten with wood screws or screw-type nails.
2. Masonry: Toggle bolts on hollow masonry units and expansion bolts on solid masonry units.
3. New Concrete: Concrete inserts with machine screws and bolts.
4. Existing Concrete: Expansion bolts.
5. Instead of expansion bolts, threaded studs driven by a powder charge and provided with lock washers may be used in existing concrete.
6. Steel: Welded threaded studs or spring-tension clamps on steel.
7. Welding to steel structure may be used only for threaded studs, not for conduits, pipe straps, or other items.
8. Light Steel: Sheet-metal screws.
9. Fasteners: Select so the load applied to each fastener does not exceed 25 percent of its proof-test load.

3.4 IDENTIFICATION MATERIALS AND DEVICES

A. Install at locations for most convenient viewing without interference with operation and maintenance of equipment.

B. Coordinate names, abbreviations, colors, and other designations used for electrical identification with corresponding designations indicated in the Contract Documents or required by codes and standards. Use consistent designations throughout Project.

C. Self-Adhesive Identification Products: Clean surfaces before applying.

D. Identify raceways and cables with color banding as follows:

1. Bands: Pre-tensioned, snap-around, colored plastic sleeves or colored adhesive marking tape. Make each color band 50-mm wide, completely encircling conduit, and place adjacent bands of two-color markings in contact, side by side.
2. Band Locations: At changes in direction, at penetrations of walls and floors, at 15-m maximum intervals in straight runs, and at 8-m maximum intervals in congested areas.
3. Colors: As follows:

    a. Fire Alarm System: Red.
    b. Security System: Blue and yellow.
    c. Telecommunication System: Green and yellow.

E. Tag and label circuits designated to be extended in the future. Identify source and circuit numbers in each cabinet, pull and junction box, and outlet box. Color-coding may be used for voltage and phase identification.

F. Install continuous underground plastic markers during trench backfilling, for exterior underground power, control, signal, and communication lines located directly above power and communication lines. Locate 150 to 200 mm below finished grade. If width of multiple lines installed in a common trench or concrete envelope does not exceed 400 mm, overall, use a single line marker.

G. Install warning, caution, and instruction signs where needed to ensure safe operation and maintenance of electrical systems and of items to which they connect. Install engraved plastic-laminated instruction signs with approved legend where instructions are needed for system or equipment operation. Install metal-backed butyrate signs for outdoor items.

H. Install engraved-laminated emergency-operating signs with white letters on red background with minimum 9-mm- high lettering for emergency instructions on power transfer, load shedding, and other emergency operations.

3.5 FIRE STOPPING

A. Apply fire stopping to cable and raceway penetrations of fire-rated floor and wall assemblies to achieve fire-resistance rating of the assembly.

3.6 CONCRETE BASES

A. Construct concrete bases of dimensions indicated or otherwise required, but not less than 100 mm larger, in both directions, than supported unit. Follow supported equipment manufacturer's anchorage recommendations and setting templates for anchor-bolt and tie locations, unless otherwise indicated. Use 21-MPa, 28-day compressive-strength concrete and reinforcement as specified in Division 3 Section "Cast-in-Place Concrete."

3.7 SUPPORT FRAMES FOR SWITCHGEAR

A. Support frames for switchgear located over cable trenches, where shown on the Drawings or required by equipment design, are to be installed prior to pouring concrete.

3.8 HOLES AND ANCHORS

A. Drilling for anchor bolts is to be carried out using appropriate electric drills and in approved positions.

B. Holes and chases in situ concrete are to be cast in. Do not cut hardened concrete or drill holes larger than 10-mm diameter without prior approval.

C. Holes and Chases in Pre-cast Concrete: do not cut or drill pre-cast concrete without prior approval.

D. Holes in Structural Steelwork: Do not cut or drill structural steelwork without prior approval.

E. Holes and chases in masonry must not exceed:

1. Size of holes: 300-mm square.
2. Depth of vertical chases: 1/3 wall thickness or, in cavity walls, 1/3 leaf thickness.
3. Depth of horizontal chases: 1/6 wall or leaf thickness.

F. Cutting Masonry:

1. Ensure mortar is fully set before commencing.
2. Cut carefully and neatly, avoiding spalling, cracking or other damage to surrounding structure.
3. Keep holes to smallest practicable size and do not exceed specified dimensions.
4. Cut chases in straight lines and horizontally and vertically only; do not set back to back; offset by a distance not less than wall thickness.

G. Preformed Holes in Masonry: Submit proposals for bridging over holes for ducts etc. which exceed 450-mm width.

3.9 CUTTING AND PATCHING

A. Cut, channel, chase, and drill floors, walls, partitions, ceilings, and other surfaces required to permit electrical installations. Perform cutting by skilled mechanics of trades involved.

B. Repair and refinish disturbed finish materials and other surfaces to match adjacent undisturbed surfaces. Install new fireproofing where existing fire stopping has been disturbed. Repair and refinish materials and other surfaces by skilled mechanics of trades involved.

3.10 FIELD QUALITY CONTROL

A. Inspect installed components for damage and faulty work, including the following:

1. Supporting devices for electrical components.
2. Electrical identification.
3. Electricity-metering components.
4. Concrete bases.
5. Electrical demolition.
6. Cutting and patching for electrical construction.
7. Touchup painting.

3.11 REFINISHING AND TOUCH UP PAINTING

A. Refinish and touch up paint. Paint materials and application requirements.

1. Clean damaged and disturbed areas and apply primer, intermediate, and finish coats to suit the degree of damage at each location.
2. Follow paint manufacturer's written instructions for surface preparation and for timing and application of successive coats.
3. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
4. Repair damage to PVC or paint finishes with matching touchup coating recommended by manufacturer.

3.12 CLEANING AND PROTECTION

A. On completion of installation, including outlets, fittings, and devices, inspect exposed finish. Remove burrs, dirt, paint spots, and construction debris.

B. Protect equipment and installations and maintain conditions to ensure that coatings, finishes, and cabinets are without damage or deterioration at time of Substantial Completion.

END OF SECTION 1000

SECTION 1001 - GROUNDING AND BONDING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Conditions of Contract and Division 1 Specification Sections, apply to this Section.

B. The following Sections contain special requirements that relate to this Section:

1. Division 100 Section "Basic Electrical Materials and Methods".
2. Division 100 Section "Conductors and Cables".

1.2 SUMMARY

A. This Section includes complete installations to earth every source of energy and to provide protective earthing and equipotential bonding, based on the TN-S system arrangement, including:

1. Transformer neutral earthing.
2. Main earthing terminals or bars.
3. Exposed conductive parts of electrical equipment.
4. Extraneous conductive parts.

Earthing requirements specified in this Section may be supplemented by special requirements of systems described in other Sections.

1.3 DEFINITIONS

A. The following terms used on the Drawings and in the Specification are equivalent and may be used interchangeably: "earth" and "ground"; "earthing" and "grounding".

B. Earth: Conductive mass of the Earth whose electric potential at any point is conventionally taken as zero.

C. Earth Electrode: Conductor or group of conductors in initial contact with, and providing electrical connection to, Earth.

D. Exposed Conductive Part: Any part which can be readily touched and which is not a live part, but which may become live under fault conditions.

E. Extraneous Conductive Part: Any conductive part not forming part of the electrical installation such as structural metalwork of a building, metallic gas pipes, water pipes, heating tubes etc. and non-electrical apparatus electrically connected to them i.e. radiators, cooking ranges, metal sinks etc. and non-insulating floors and walls.

F. Protective Conductor: Conductor used for some measure of protection against electric shock and intended for connecting together any of the following parts:

1. Exposed conductive parts.
2. Extraneous conductive parts.
3. Earth electrode(s).
4. Main earthing terminal or bar(s).
5. Earthed point of the source(s).

G. Electrically Independent Earth Electrodes: Earth electrodes located at such distance from one another that maximum current likely to flow through one of them does not significantly affect the potential of the other(s).

H. Main Earthing Terminal or Bar: The terminal or bar provided for the connection of protective conductors, including equipotential bonding and functional earthing conductors if any to the means of earthing.

I. Equipotential Bonding: Electrical connection to put exposed and extraneous conductive parts at a substantially equal potential.

J. Earthing Conductor: Protective conductor connecting main earthing terminal or bar of an installation to earth electrode or to other means of earthing.

1.4 SUBMITTALS

A. Product Data: Prior to ordering materials, submit data for approval including, but not limited to, manufacturer's catalogues for each type of product indicated including the following:

1. Ground rods.
2. Connecting clamps.
3. Earthing conductors, protective conductors, and bonding conductors.
4. Connectors and other accessories.
5. Exothermic welding kits and tools.

B. Qualification Data: For firms and persons specified in "Quality Assurance" Article to demonstrate their capabilities and experience. Include lists of completed projects with project names and addresses, names and addresses of architects/engineers and owners, and other information specified or required by Engineer.

C. Field Test Reports: Submit written test reports to include the following:

1. Test procedures used and test conditions.
2. Test results that comply with requirements.
3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

D. Shop and Construction Drawings: Submit drawings for approval including, but not limited to, the following:

1. Exact location of earth pits, rods and details of installation and connections.
2. Exact routing of buried earthing conductors with indication of cross-section, depth of laying and covering.
3. Cross sectional area of all earthing, protective and bonding conductors.
4. Layout and details of earthing provisions at substations, switchgear, distribution panelboards etc., indicating fittings used, insulation, plates and marking, passage and routing of earthing conductors, conduit, sleeves, grooves, niches etc., giving sizes and dimensions of component parts.

E. Records: Submit the following:

1. Scaled drawings, as-installed, showing actual layout and specification of all components of earthing system.
2. Nature of soil and any special earth arrangements etc.
3. Date and particulars of soil conditioning method and agents if used.

F. Samples: Submit samples of conductors, as requested by Engineer.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: Engage an experienced installer who has specialized in installing lightning protection systems similar in material, design and extent to those indicated for this Project and whose work has resulted in installations with a record of successful in-service performance.

B. Standards: Carry out work in accordance with the following:

1. IEC 60364-3 and 60364-4-41: Electrical Installations in Buildings.
2. Latest edition IEE Regulations for Electrical Installations in Buildings – London.

C. Comply with BS 6651 when interconnecting with lightning protection system.

PART 2 - PRODUCTS AND SYSTEMS

2.1 MANUFACTURERS:

A. Approved Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

1. BICC (England)
2. Copperweld (U.S.A.)
3. Furse (England)
4. A.N. Wallis (England)

2.2 GENERAL REQUIREMENTS

A. Component parts of earthing system are to include the following:

1. Earth electrode (rods, tapes etc.)
2. Main earthing terminals or bars.
3. Earthing conductors.
4. Protective conductors.
5. Equipotential bonding conductors.
6. Electrically independent earth electrodes for special systems.
7. Accessories and termination fittings, bonding, welding kits and other materials.

B. Earth electrode is to consist of one or more earth rods, interconnected by buried earthing tape or cable, which is to have a total combined resistance value, during any season of the year and before interconnection to other earthed systems or earthing means, not exceeding 5 ohms. Distance between two rods is not to be less than twice the length of one rod driven depth.

C. Ring type earth electrode is to consist of earthing conductors, in a closed loop, buried in exterior wall foundations underneath the water-proofing, or alternatively at 0.6 m around the perimeter of the building foundations, as shown on the Drawings. Connect all earthing conductors to this ring. Insulated connection flags into the building, of same material as earthing conductors, are to be located at positions of service entrance and main switchboard rooms, terminating in bolt-type earth points (studs) or test- links for connection of main earth bar(s). Additional earth rods connecting with the earth ring are to be provided, as necessary, to bring down earth electrode resistance to an acceptable value.

D. Functional earth electrode is to be provided separately from, but interconnected to, other earth electrode(s) through suitably rated (470 V) spark gap. Functional earth electrodes are to be used for earthing electronic equipment (communication equipment, digital processors, computers etc.) as required by the particular Section of the Specification and recommendation of manufacturer.

E. Alternative Earth Electrode: other types of earth electrode may be used, after approval, including:

1. Cast iron pipes with special surround material
2. Copper plate(s)
3. Tape mats (strips).

F. Main earthing bar is to be provided at point of service entrance or main distribution room, and as described in the Specification or shown on the Drawings. Connect all earthing conductors, protective conductors and bonding conductors to the main earthing bar. Provide two insulated main earthing conductors, one at each end of the bar, connected via testing joints to the earth electrode at two separate earth pits. Conductor is to be sized to carry maximum earth fault current of system at point of application with final conductor temperature not exceeding 160 deg. C for at least 5 seconds. Main earthing conductors are to be minimum 120 mm2 or as otherwise required by the particular Section of the Specification.

G. Testing joints (test links) are to be provided, in an accessible position, on each main earthing conductor, between earthing terminal or bar and earth electrode.

H. Protective conductors are to be separate for each circuit. Where protective conductor is common to several circuits, cross-sectional area of protective conductor is to be the largest of the conductor sizes.

1. Selection of sizes is to be in accordance with Table 54F of IEE Regulations.

I. Protective conductors are not to be formed by conduit, trunking, ducting or the like. Where armored cable is specified and armor is steel, it may be used as a protective conductor, if approved and if not otherwise shown on the Drawings.

J. Continuity of Protective Conductors: Series connection of protective conductor from one piece of equipment to another is not permitted. Extraneous and exposed conductive parts of equipment are not to be used as protective conductors, but are to be connected by bolted clamp type connectors and/or brazing to continuous protective conductors which are to be insulated by molded materials.

K. Earth Fault Loop Impedance: For final circuits supplying socket outlets, earth fault impedance at every socket outlet is to be such that disconnection of protective device on over-current occurs within 0.4 seconds. For final circuits supplying only fixed equipment, earth fault loop impedance at every point of utilization is to be such that disconnection occurs within 5 seconds.

1. Use appropriate tables and present same for approval by the Engineer (IEE Regulations: Tables 41A1 and 41A2, Appendix 7 and Regulation 543).

L. Supplementary Equipotential Bonding: Connect all extraneous conductive parts of the building such as metallic water pipes, drain pipes, other service pipes and ducting, metallic conduit and raceways, cable trays and cable armor to nearest earthing terminals by equipotential bonding conductors. Cross-section of protective bonding conductor shall not be less than half of the protective conductor connected to respective earthing terminal with a minimum of 4-mm2.

M. Main Equipotential Bonding: Main incoming and outgoing water pipes and any other metallic service pipes are to be connected by main equipotential bonding conductors to main earth terminal or bar. Bonding connections are to be as short as practicable between point of entry/exit of services and main earthing bar. Where meters are installed, bonding is to be made on the premise side of the meter. Cross-sections of conductors are not to be less than half that of the earthing conductor connected thereto, and minimum 6 mm2.

N. Identification: Connection of every earthing conductor to earthing electrode and every bonding conductor to extraneous conducting parts is to be labeled in accordance with the Regulations, as follows:

1. SAFETY ELECTRICAL CONNECTION - DO NOT REMOVE.

O. Identification: Protective and earthing conductors are to be identified by combination of green-and-yellow colors of insulation or by painting bar conductors with these colors, as approved.

P. Identification: Source earthing conductor (or neutral earthing conductor) is to be identified along its entire length by continuous black insulation labeled 'neutral earthing'.

2.3 GROUNDING CONDUCTORS

A. Buried Earth Conductors: Bare annealed copper strip conductors 25 x 2.5 mm, or annealed stranded copper conductors as shown on drawings.

B. Earthing Conductors: Insulated or bare copper conductor as described in the Specification for the particular application.

C. Protective Conductors: Single core stranded annealed copper, PVC insulated cables, having rated insulation grade compatible with circuit protected, or to be a conductor forming part of a multi-core cable, color coded.

D. Protective Bonding Conductors: Bare copper strip conductor, annealed stranded copper cable or flexible strap (flexible braid) of cross-sectional area as described in Article "General Requirements" hereof.

E. Main Earthing Bar: Hard drawn copper, 40 x 4 mm where formed into a closed loop, and 50 x 6 mm where open-ended. Earth bar is to be labeled 'Main Earth Bar' and is to be drilled, for connection of conductors, at a spacing not less than 75 mm, and is to be supplied with copper alloy bolts, nuts and washers and wall mounting insulators.

F. Testing Joints (Test Links): Copper or copper alloy, with bolted end connections, disconnectable by use of a tool, and suitably sized for earthing conductors or earth bar connection. Links are to be fixed to porcelain or other approved insulating supports. Contact surfaces are to be tinned.

2.4 CONNECTOR PRODUCTS AND EARTHING ACCESSORIES

A. Copper or copper alloy, purpose made, of approved design, compatible with points of connection, and of adequate cross-section and current carrying capacity.

B. Bolted Connectors and Clamps: Bolted-pressure-type connectors and clamps, or compression type. Bolts, nuts and washers are to be high quality phosphor bronze or copper silicon alloys.

C. Welded Connectors: Exothermic-welded type, in kit form, and selected per manufacturer's written instructions.

2.5 GROUNDING ELECTRODES

A. Ground Rod: 16-mm diameter high strength, low carbon steel core of high tensile strength (600 N/mm2), with 99.99% pure electrolytic copper molecularly bonded into steel core, 0.25 mm minimum thickness. Driving head is to be high strength steel. Couplings are to be long length silicon bronze, internally threaded. Threads are to be rolled onto rod to ensure uniform layers of copper and strength. Earth rod is to be complete with couplings, head and bolted connector of sufficient size, and number of bolted clamps to connect all cables terminated thereto.

1. Minimum Length of Rod: 2.5 m, extendible as necessary to obtain required earth resistance

B. Earth Pit: Precast, square or circular section concrete handhole (minimum 450 mm internal diameter), with concrete cover, and extending to about 150 mm below top of earth rod. Earth pit is to be provided for each earth rod where connected to an earthing conductor. Cover is to have inset brass plate with inscription 'Earth Pit - Do Not Remove'.

PART 3 - EXECUTION

3.1 TRANSFORMER SUBSTATION EARTHING

A. MV switchgear is to have separate main earthing bar connected to framework or earth bar of each item by bare conductor and the earth-electrode by two insulated earthing conductors, one at each end of bar, via testing joints. Earthing conductor is to be minimum 50 mm2.

B. Ring main units, which are individually mounted, are to be connected to earth electrode by one insulated earthing conductor, bolted at earthing terminal.

C. LV switchgear is to have separate main earthing bar connected to framework or earth bar of each item by bare conductor and the earth electrode at two extreme ends by two insulated earthing conductors through testing joints. Earthing conductor size is to be minimum 120 mm2.

D. Transformer earthing terminal is to be connected to LV main earthing bar by bare copper earthing conductor not less than 20 mm2 per 100 kVA of transformer rating, with a minimum of 35 mm2.

E. Transformer neutral (star point) is to be connected by insulated earthing conductor (color black) to LV side main earthing bar. Neutral earthing conductor is to be sized for maximum earth fault current for 5 seconds with final conductor temperature not exceeding 160 deg. C or sized not less than 30 mm2 per 100 kVA of transformer rating, and with a minimum of 50 mm2. Where a neutral is directly connected to earth electrode, an insulated disconnecting device is to be provided at the transformer.

F. Lightning arresters are to be directly connected to earth electrode, following the shortest path. Each lightning arrester is to be connected at a dedicated earth rod.

3.2 EARTHING OF MAIN DISTRIBUTION BOARDS, PANELBOARDS, LIGHTING INSTALLATIONS AND WIRING ACCESSORIES

A. Main earthing bar is to be provided in main distribution room and connected to earth electrode by two insulated conductors (minimum 120 mm2) via testing joints.

B. Earthing bars of main distribution boards are to be connected, by bare earthing conductor, directly to main earthing bar at main distribution room and by protective conductor run with incoming feeder from respective supply point.

C. Distribution, lighting and power panelboards are to be connected by protective conductors run together with incoming feeder cable, connecting earth terminals in panelboards with respective main distribution board earthing bar.

D. Socket outlets are to be earthed by protective conductor run with the branch circuit and connected to earth terminal within socket outlet box and to which socket outlet terminal is to be connected.

E. Lighting fixtures and other exposed conductive parts of electrical installations, such as switches, heaters, air conditioning units etc. are to be connected by protective earth conductors to earthing terminals of respective panelboards.

3.3 MECHANICAL PLANT ROOMS AND FIXED MACHINERY

A. Main earthing bar or loop is to be conveniently located in mechanical plant rooms, and connected by earthing conductors to exposed conductive parts of motor control centre at its earthing bar, and to motors, switches and other electrical equipment etc. at their earthing terminals, using 20 x 2 mm bare copper strips or 35 mm2 bare copper conductor (minimum size) or as required to carry maximum earth fault current for 1 second with final conductor temperature not exceeding 200 deg. C. Conductors are to be securely fixed, recessed in floor grooves or niches, or fixed to walls by appropriate staples. Earth bar or loop is to be securely fixed to building wall with copper or brass saddles.

B. Main earthing bar or loop is to be connected at two extremely separate points to earth electrode, directly through two test joints by insulated earthing conductors, or connected to main earth bar by protective conductors.

C. Motor and other equipment earth terminals are to be connected also by protective earth conductors of each branch circuit to earth terminal/bar at motor control centre, panel or distribution unit.

3.4 ROAD LIGHTING

A. Earthing Cables: separate protective earthing cables for lighting column circuits are to be run with power circuit, terminated at LV supply position in lighting control panel and looped into column earthing terminals. The last column is to be bonded via an earthing bolt to a single 14 mm diameter copper

covered steel rod, 2.5 m long, driven into ground adjacent to column. Bonding is to be 16 mm2 stranded bare copper conductor.

B. Connections between rods and earthing conductors are to be made by the Cadweld process producing a fused joint. Bolted connections may be used for connection to removable items of equipment only.

3.5 SIGNAL AND COMMUNICATION SYSTEMS

A. Signal and Communication Systems: For telephone, alarm, voice and data, and other communication systems, provide 16mm2 minimum insulated grounding conductor in raceway from grounding electrode system to each service location, terminal cabinet, wiring closet, and central equipment location.

1. Service and Central Equipment Locations and Wiring Closets: Terminate grounding conductor on a 6.4-by-50-by-300-mm grounding bus.
2. Terminal Cabinets: Terminate grounding conductor on cabinet grounding terminal.

3.6 INSTALLATION

A. Continuity: Ensure that complete earthing system is electrically continuous and mechanically secure.

B. Earth Rods: While siting earth rods, ensure that resistance areas associated with individual rods do not overlap. Earth rods are to be located at a distance greater than 600 mm from foundations of buildings. Where rock is encountered, a hole of sufficient size is to be drilled before lowering the rod. Conductive filler such as Marconite or Bentonite or equal filler that will not corrode, is to be provided around the rod.

C. Buried earthing conductors are to be laid at a depth not less than 0.8 m from ground surface.

D. Earthing conductors are to follow shortest path between earth rods and main earthing terminals or bars, and are to run in PVC conduit (duct) fastened to building structure by approved supports and extending 0.2 m above level, and are to be protected against mechanical damage and corrosion.

E. Protective Conductors: Separate protective conductors, which are not part of a cable, are to be fixed on same support or drawn into same conduit as circuit conductors.

F. Protective Bonding: Remove any non-conductive paint, enamel or similar coating at threads, contact points and surfaces and ensure that bonding is made by fittings designed to make secure bonds.

3.7 CONNECTIONS

A. Protection against Corrosion: Protect bolted connections against corrosion either by filling with Vaseline or coating with a special anti-corrosion compound and proper capping.

B. Connections: Earth connections are to be readily accessible. If inaccessible earth connection is permitted, approved exothermic welding or brazing technique is to be employed.

C. Connections: Where earth connections between dissimilar metals must be made, use bimetallic fittings and protect by coating with moisture resisting bituminous paint or compound, or by wrapping with protective tape to exclude moisture.

D. Exothermic-Welded Connections: Comply with manufacturer's written instructions. Welds that are puffed up or that show convex surfaces indicating improper cleaning are not acceptable.

E. Tighten screws and bolts for grounding and bonding connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in applicable Standards.

3.8 FIELD QUALITY CONTROL

A. Combined resistance of earth electrodes is to be measured during dry season and checked against specified resistance.

B. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Engineer promptly and include recommendations to reduce ground resistance.

C. Electrical continuity of all earthing and protective conductors including main and supplementary equipotential bonding conductors is to be checked.

D. Earth fault loop impedance of all circuits is to be measured and checked against calculated impedance figures.

E. Operation of residual current protective devices is to be checked.

3.9 GRADING AND PLANTING

A. Restore surface features, including vegetation, at areas disturbed by Work of this Section. Reestablish original grades, unless otherwise indicated. If sod has been removed, replace it as soon as possible after backfilling is completed. Restore areas disturbed by trenching, storing of dirt, cable laying, and other activities to their original condition. Include application of topsoil, fertilizer, lime, seed, sod, sprig, and mulch. Comply with Division 2 Section "Landscaping." Maintain restored surfaces. Restore disturbed paving as indicated.

END OF SECTION 1001

SECTION 1002 – LOW VOLTAGE CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Conditions of Contract .

1.2 SUMMARY

A. This Section includes low voltage (LV) feeder cables, branch circuit wiring, control and signal cables, termination, jointing and splicing.

B. Related Sections include the following:

1. Division 100 Section "Basic Electrical Materials and Methods".

1.3 SUBMITTALS

A. Technical Data: Submit data for approval including, but not limited to, the following:

1. Constructional details, standards to which cables comply, current carrying capacities, de-rating factors for grouping and temperature.
2. Manufacturer's catalogue cuts.
3. Dimensional and electrical characteristics.

B. Samples of each cable and wire and, if requested by Engineer, other accessories.

C. Shop and Construction Drawings: Submit drawings for approval including, but not limited to, the following:

1. Exact routing layouts, sections and profiles of trays, feeder, sub-feeder cables and branch circuits, with indication of any equipment to show and verify coordination between various trades.
2. Details of supports and fixings for buses, trays and cables.
3. Details of connections to transformers, switchboards, panelboards etc.
4. Details of terminations, splices and tapings where permitted, glands and bushings at enclosures.
5. Number and size of conductors in conduit for all branch circuits in accordance with final conduit routing.

D. Certificate of Origin: For each lot of cable supplied, provide a certificate of origin issued by manufacturer stating origin, date of manufacture, composition, standards to which it complies and test certificates. All test certificates are to comply with the test requirements of the relevant standard to which the cable is manufactured.

E. Cable Jointing Qualifications: Submit details of the proposed cable jointers qualifications prior to work commencing on site.

F. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: Engage an experienced and certified cable splicer to install, splice and terminate low-voltage cables.

B. Standards: Wires and cables are to comply with IEC or other equally approved standards and are to bear the mark of identification of the Standards to which they are manufactured. Wires and cables not having this identification will be rejected.

C. Current carrying capacities of conductors have been determined in accordance with the Regulations for specified type of insulation and expected conditions of installation. No change will be accepted in specified type of insulation unless warranted by special conditions and approved by Engineer. Check various loads and current carrying capacities and report any discrepancies or insufficiency of sizes indicated to Engineer.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver wires and cables properly packaged in factory packed or fabricated containers, wound on factory reels.

B. Store wires and cables in dry areas, and protect from weather, fumes, water, debris, etc.

C. Handle wire and cable carefully to avoid abrasing, puncturing and tearing wire and cable insulation and sheathing. Ensure that dielectric resistance integrity of wires/cables is maintained.

1.6 COORDINATION

A. Coordinate layout and installation of cables with other installations.

B. Revise locations and elevations from those indicated, as required to suit field conditions and as approved by Engineer.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Approved Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

1. B.I.C.C. (Egypt)
2. EL-sweedy helal (Egypt))
3. Egypt cables (Egypt)
4. El-Sweedy industries (Egypt)

2.2 GENERALLY

A. Conductors: Unless otherwise specified or shown on the Drawings, cables and other feeders are to have copper conductors. Cable conductors are to be stranded for sections 2.5 mm2 and above, based on IEC 60228 Class 2. Signal and control cables are to have solid conductors unless otherwise specified. Flexible cords are to have finely stranded conductors. Conductors of single-core cables 25-mm2 and above are to be compacted. Multi-core cables 35-mm2 and above are to be sectoral shape.

B. Conductor sizes are to be metric and as shown on the Drawings. Conductors with cross-sectional area smaller than specified will not be accepted.

C. Building wiring insulation is to be color coded or otherwise identified as required by the Regulations and as follows:

1. Neutral is to be light blue or white.
2. Protective earth is to be green or green/yellow striped.
3. Phase colors are to be to local Regulations and consistent throughout the installation, or use color coding in accordance with local regulations and standards.

D. Maintain color coding throughout installation. Phase-conductors for which outer jacket is not color-coded are to have engraved alphanumeric mark (L1, L2, L3) or color coded heat-shrinkable sleeves.

E. Buried Cables: Cables buried directly in the ground are to be armored type, unless otherwise indicated in particular Sections of the Specification or on the Drawings.

2.3 LV WIRES AND CABLES

A. Single Core PVC Insulated Cables (Building Wires): Unless otherwise specified, single conductor cables for wiring in conduit are to have annealed copper conductors, compacted, generally with concentric

strands and insulated with flame retardant, moisture resistant PVC/C to IEC 60227 (type 5 to BS 6746), suitable for wet locations and for conductor temperature of 70 deg. C. Wires and cables are to be 450/750 V grade.

B. Multi Core PVC Insulated Cables (0.6/1 kV): To have annealed, copper conductors, compacted, insulated with PVC/C to (type 5 to BS 6746), moisture resistant, suitable for wet locations and conductor temperatures of 70 deg. C, laid up, bedded with suitable filler and sheathed with flame retardant PVC/ST2. Armored cables are to have single layer of galvanized steel wire armor with fame retardant PVC/ST2 over-sheath. Cables are to comply with IEC 60502, IEC60332-1 and IEC 60811.

C. Single-core circular stranded, annealed copper conductors, compacted, insulated with flame retardant, moisture resistant cross-linked polyethylene (XLPE), suitable for wet locations and conductor temperatures of 90 deg. C. and PVC over-sheath. Armored cables are to have taped bedding, single wire aluminum armor and PVC over-sheath.

D. Multi-Core XLPE Insulated Feeder Cables (0.6/1 kV): Multi core annealed copper conductors, compacted, XLPE insulated, for conductor temperature of 90 deg. C, laid up and bedded with suitable non-hygroscopic material compatible with the insulation and PVC over-sheathed, color black. Armored cables are to have single layer of galvanized steel wire applied helically over extruded PVC bedding (which may be an integral part of filling) and over-sheathed with PVC, color black. PVC over-sheaths are to be type ST2 to IEC 60502.

E. Flexible cable for connection to appliances, window fans, pendants etc. is to be 300/500 V grade to BS 6500, three or four core, with tinned finely stranded copper wires, EPR insulated, twisted and Sheathed With Chlorosulphonated Polyethylene (CSP) Compound And With Strengthening Cord.

F. Fire resistant Cable (HT-1) (similar to Perilli - Type FP 200 Gold, or approved equal): Solid or stranded plain annealed copper conductors to BS 6360 (in sizes up to 4 mm^2), fire resistant insulation to BS 6899 (0.6 mm radial thickness), laminate aluminum/screen and Low Smoke Zero Halogen (LS0H) composite sheath with tinned earth continuity conductor/drain wire. Cable is to be rated 300/500 V, capable of accepting voltage surges up to 5 kV, to operate continuously at 150 deg. C and for short durations at 200 deg. C. It is to be certified to have passed IEC 60331 and IEC 60332-1 and IEC 60332-3 flame resistance fire retardant and reduced flame propagation tests and to comply with category CWZ of BS6387 .

G. Fire resistant cable (HT-2) (similar to Perilli FP-400 or equal) : plain copper stranded circular conductor complying with BS 6360 with fire resistant insulation comply with BS 7655 operating temperature 90ºC, galvanized steel wires armour and extracted low smoke zero halogen (LS0H) over sheath . Cables are to be rated 600/1000 V. It is to be certified to have passed IEC 60331, IEC 60332-1 and IEC 60332-3 and IEC fire retardant and reduced flame propagation test and to comply with category CWZ of BS 6387. Cables are to be sued to feed the fire pumps.

2.4 CONTROL AND SIGNAL CABLES

A. Multi-Core PVC Insulated Control Cables: 0.6/1 kV rating, solid 1.5 mm2, 2.5 mm2 or stranded 4 mm2 plain circular copper conductors, with heat resistive PVC/E to IEC 60227 (PVC type 5 to BS 6746), rated for 85 deg. C, of 7, 12, 19, 24, 30 or 37 cores. Cores are to be laid up together and filled with non-hygroscopic material, PVC over-sheathed, to form compact and circular cable for use in switchgear, control gear and generally for control of power and lighting systems. Armored cable is to have extruded PVC bedding which may be an integral part of the filling, galvanized steel wire armoring, and over-sheath

of PVC type ST2 to IEC 60502, color black. Core identification is to be white printed numbers 1, 2, 3 etc. over black insulation.

B. PE insulated control and signal cables, for use on data systems, are to be generally 300 V rating, polyethylene insulated, color-coded, tinned copper conductors (0.6-mm diameter), twisted together into pairs. Multi-pair core assembly is to be covered with binder tape, spirally wound 0.075-mm bare copper shielding tape and provided with drain wire and overall PVC sheath.

C. Control and signal cables, enclosed in conduit and raceways with power cables, are to be insulated for same voltage grade.

2.5 CONNECTORS (LV POWER)

A. Connector - Type A-1: Pressure indent type, for terminating or making T-taps and splices on conductors 10 mm2 and smaller. Connector is to be non-ferrous copper alloy applied to conductor by mechanical crimping pressure, with vinyl insulating sleeves or phenolic insulating covers.

B. Connector - Type A-2: Bolted pressure split type for terminating or making T-taps and splices on conductors 16 mm2 and larger. Connector is to be cast non-ferrous copper alloy applied to conductor by clamping with minimum of two screws and provided with phenolic insulating cover.

C. Connector - Type B-1: Pre-insulated, spring type, for branch circuit and fixture wiring. Connector is to be steel encased spring with shell, insulated with vinyl cap and skirt, type Scotchlok brand, as manufactured by Minnesota Mining & Mfg. Co. or other equal and approved.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine raceways and building finishes receiving wires and cables for compliance with requirements for installation tolerances and other conditions affecting performance of wires and cables. Do not proceed with installation until unsatisfactory conditions have been corrected.

B. Before pulling wires in conduit check that inside of conduit (and raceway in general) is free of burrs and is dry and clean.

3.2 INSTALLATION

A. General: Building wires and cables are to be installed in conduit, trunking or ducts indoors and in conduit outdoors, unless otherwise shown the Drawings.

B. Circuits: Unless otherwise shown on the Drawings, final branch circuit wiring is to be run inside trunking or conduits, D.C. wiring is to be run in separate conduits from A.C. wiring, and emergency lighting and power circuits are to be run in separate conduits from normal circuits.

C. Branch circuit work originating from light and power panelboards is to be arranged as shown on the Drawings. Loads on various phases of panelboards are to be balanced. Ensure that the lighting load and other loads are balanced with a difference of not more than 10% between the phases.

D. Control cables may be fixed to racks, installed directly on cable trays or pulled in conduit and trunking indoors, and in underground ducts or in conduit outdoors.

E. Bunching of wires in raceways is to be in accordance with raceway filling factors permitted by the Regulations.

F. Lubricants are to be used for pulling wire or cable if character of pull would otherwise damage conductors, insulation or jacket. Lubricants are to be approved by the Engineer.

G. Pull conductors into raceways simultaneously where more than one is being installed in the same raceway.

H. Support: Cables and wires pulled inside very high conduit risers are to be supported at upper end of risers and at intermediate points by split rubber grommets to relieve any stresses on conductors, where required.

I. Wiring At Outlets: Leave a slack of at least 200mm at each outlet.

J. Extra Length: At every branch circuit outlet and pull-box, every cable passing through is to be left slack to allow inspection and for connections to be made. Cables terminating in outlet boxes are to be left with at least 250-mm extra length for terminations.

K. Joints or taps in wires and cables, if permitted, are to be permanently accessible or made only in boxes or cabinet gutters.

L. Connectors for terminating or making T-taps and splices are to be Type A-1 on conductors 10 mm2 or smaller, Type A-2 for conductors 16 mm2 and larger, and Type B-1 for branch circuit and fixture wiring.

M. Insulating covers are to be applied to prevent exposure of bare cable connections.

N. Switch legs for local wall switches are to have distinctive color, selected as complementary to cable color coding used in the project.

O. Terminations: Conductors of wires and cables up to 16mm2 are to be tightly twisted and where possible doubled back before being clamped with set screws. Where two or more wires are looped into same terminal these conductors are to be tightly twisted together before inserting into terminals. In no case is bare conductor to be allowed to project beyond any insulated shrouding or mounting of a line terminal. Cables sizes 16 mm2 and larger are to terminate in tunnel lugs with setscrew, or by using bolted or sweated compression connectors.

P. Tagging: Tag main and feeder cables in pull-boxes, wireways and wiring gutters of panelboards or distribution cabinets. Tags are to identify cable or circuit number and conductor size in accordance with the Schedules.

Q. Tagging: Where two or more circuits are run to or through a control device, outlet box or ceiling junction box, each circuit is to be tagged as a guide in making connections.

3.3 FEEDER AND SUB-FEEDER INSTALLATION (0.6/1 KV)

A. Cables generally are to be run through duct-banks, shafts or special recesses, clamped to steel racks or cable trays. Cables run through ventilation shafts are to be installed in steel conduits.

B. Fixing: Single cables above suspended ceilings or in concealed spaces are to be fixed directly to walls or ceilings but must be accessible. Where two or more cables are run in parallel, they are to be fixed on galvanized steel perforated trays or on other approved special cable supporting and protecting arrangement.

C. Clamps: Where cables are fixed to steel trays or supporting structures, approved galvanized cast steel clamps (or molded plastic clamps for single core cables) are to be used at distances not exceeding 20 diameters.

D. Joints or splices will not be accepted on main and sub-feeders. Cables are to be supplied in lengths sufficient for straight-through un-jointed termination to termination pull.

E. Directly buried cables crossing under roads, pipe banks or other services, are to be laid in heavy duty PVC duct banks. In no case are cables to be directly buried in concrete, in masonry or in floor finishing.

F. Buried cables liable to mechanical damage are to be drawn through PVC conduit or asbestos cement pipe. If steel conduit is used, all three-phase conductors, neutral and protective earth circuits are to be in the same conduit.

G. Exposure to Heat: Route wires and cables to prevent exposure to excessive heat or to corrosive agents. If such condition is unavoidable, cables are to be type designed for particular condition.

H. Insulating covers are to be applied to prevent exposure of bare cable connections. Insulating cover is to be purpose made and is to provide minimum insulation level equal to that of conductor insulation.

I. Glands for various single-core and multi-core cables are to be purpose made and suitable for rigid mounting to equipment enclosure.

J. Seal around cables penetrating fire-rated elements using approved fire-stopping material according to Division 7 Section "Through-Penetration Firestop Systems".

K. Identify wires and cables according to Division 16 Section "Basic Electrical Materials and Methods."

3.4 CONNECTIONS

A. Through joints will not be allowed in feeder cables where adequate manufacturer's lengths are available. Where a joint is necessary, it has to be made inside boxes, hand holes or manholes.

B. Recommendations: Through joints and terminations are to be carried out strictly in accordance with cable manufacturer's recommendations, and made with correct specified materials, boxes, tapes, compounds or mixtures, stress cones, glands and bonds as applicable.

C. Jointing: Joints are to be filled with epoxy resin after taping unless contrary to cable manufacturer's recommendations. Sample site constructed cable terminations and through-joints are to be submitted prior to commencing work on site. Samples are to be constructed in the presence of the Engineer and are to be available for test and inspection in accordance with manufacturer's recommendations.

D. Cutting tools for jointing and terminating cables are to be purpose made, to prevent damage to insulation in general, and to cable shielding of MV cables.

E. Cleaning of lacquer on conductors is to be by use of 'Scotch Brite' sponge and white spirit or equal approved.

F. Tighten electrical connectors and terminals including screws and bolts, in accordance with manufacturers published torque-tightening values. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals to comply with international standards.

3.5 FIELD QUALITY CONTROL

A. Cable tests are to be carried out in accordance with the requirements of the Regulations and Standards.
B. Test Equipment: Provide megger testers of various ranges as applicable, and HV test equipment as necessary for testing MV installations. Use 500 V megger on installations with nominal voltage up to 500 V, and 1000 V megger on installations with nominal voltage over 500 V up to 1000 V.
C. Insulation resistance for LV power and lighting installations is to be carried out in accordance with IEE Regulations 613-5 through 613-8 and 713-04.
D. Insulation resistance for control and signal cables is to be minimum 10000 Megohm-km for PE insulated cables and 100 Megaohm-km for PVC insulated cables, all measured core-core and core-earth, in accordance with the Regulations.
E. Prior to energization of circuitry, check installed wires and cables with megohm meter to determine insulation resistance levels to ensure requirements are fulfilled.
F. Prior to energization, test wires and cables for electrical continuity and for short-circuits.
G. Subsequent to wire and cable hook-ups, energize circuitry and demonstrate functioning in accordance with requirements. Where necessary, correct malfunctioning units, and then retest to demonstrate compliance.

END OF SECTION 1002

SECTION 1003- RACEWAYS AND BOXES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Conditions of Contract apply to this Section.

1.2 SUMMARY

A. This Section includes boxes and raceways including conduits, wireways, and related installations and accessories necessary to support and protect cables, feeders, sub-feeders, branch circuit wiring and wiring of low current systems, communications and signal cables.

B. Related Sections include the following:

1. Division 100 Section "Basic Electrical Materials and Methods" for raceways and box supports.
2. Division 100Section "Wiring Devices" for devices installed in boxes and for floor-box service fittings.

1.3 SUBMITTALS

A. Product Data: Submit data for approval including, but not limited to, manufacturers' catalogues with specifications of raceways including conduits, trunking, boxes, etc. and related accessories

B. Shop and Construction Drawings: Submit drawings for approval including, but not limited to, the following:

1. Exact routing of conduits, trunking etc. with indication of boxes, accessories and expansion joints, size and type of conduits and boxes.
2. Typical assembly details of installation of trunking, trays etc.
3. Construction details of pull boxes.
4. Typical installation details including connection of conduits to metal enclosure, connection of flexible conduits, vapour-tight installations in cold rooms, weatherproof installations outdoors etc. and earthing connections.

C. Samples of each type of raceway, box, and accessory.

1.4 QUALITY ASSURANCE

A. Regulations and Standards: Conduits, wireways, cable trays and fittings are to be designed, constructed and installed to give safe installation and reliable mechanical protection for wires and cables in accordance with the Regulations. Standards of products are to be as specified.

1.5 COORDINATION

A. Coordinate layout and installation of raceways and boxes with other construction elements to ensure adequate headroom, working clearance, and access.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Approved Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

1. PVC conducting system

a. Engineering Home (Egypt)
b. Alaa Eldin (Egypt)

2. Metallic conducting system and accessories

a. Allied tube (USA)
b. Steel City. (USA)
c. Barton (England)
d. Wheatland (UK)

2.2 RIGID HEAVY GAUGE STEEL CONDUIT

A. Material: Heavy gauge drawn and welded steel, threaded at both ends, to CEE 23, BS 4568 Part 1 and BS 31 Class B (threaded), with class 4 protection for rigid steel conduit, zinc coated inside and outside by hot-dip process or sherardizing.

B. Fittings Generally: Threaded type, galvanized or cadmium plated malleable cast iron. Fittings used in corrosive atmospheres are to be specially treated. Fittings and components are to comply with CEE 23, BS 4568 Part 2 and BS 31.

C. Locknuts for securing conduit to metal enclosure are to be heavy hexagonal or castellated pattern, for fastening.

D. Bushings for terminating conduits are to be smooth rounded brass rings.

E. Miscellaneous fittings including reducers, chase nipples, three piece unions, split couplings and plugs are to be standard fittings designed and manufactured for the particular application.

2.3 LIGHT GAUGE STEEL CONDUIT (ELECTRICAL METALLIC TUBING-EMT)

A. Material: Welded steel, non-threaded type, galvanized externally and protected internally with corrosion resistant enamel, and to U.S. Federal Specifications.

B. Corrosion Resistance: Conduits used in corrosive atmospheres are to be copper silicon alloy, highly resistant to corrosion.

C. Fittings Generally: Threadless pressure type, galvanized or cadmium plated malleable cast iron. Fittings used in corrosive atmospheres are to be specially treated.

2.4 FLEXIBLE STEEL CONDUIT

A. Material: Steel, cold rolled and annealed, non-threaded type, formed from continuous length of helically wound and interlocked strip steel, with fused zinc coating on inside and outside, and to BS 731.

B. Liquid-tight flexible conduit is to have PVC jacket extruded over core.

C. Fittings Generally: Threadless, hinged clamp type, galvanized or cadmium plated malleable cast iron. Fittings used in corrosive atmospheres are to be specially treated.

D. Straight Connectors: One piece body, female end, having hinged clamp and deep slotted machine screws for securing to conduit, male end having thread and locknut.

E. Angle connectors of 45 or 90 degree and terminal connectors are to be as specified for straight connectors, except that body is to be two-piece with removable upper section.

2.5 RIGID HEAVY GAUGE PVC CONDUIT

A. Material: Rigid unplasticized polyvinyl chloride with high impact and high temperature resistance, flame retardant, non-hygroscopic and non-porous, to CEE 26, BS 4607 and BS 6099, DIN 49016 or other equal and approved standards conforming to IEC 60423, 60614-1 and 60614-2-2.

B. Fittings Generally: Unbreakable, non-inflammable, self extinguishing, heavy moulded plastic. Expansion couplings are to be telescoping double tube type, with at least two inner water-tight neoprene rings.

C. Assembly: Conduits, boxes and accessories are to be assembled by cementing, using manufacturer's recommended products and appropriate connectors or spouts. Where no spouts are available use smooth bore male PVC bushes and sockets.

2.6 FLEXIBLE PVC CONDUIT

A. Material: Flame retardant, heat resistant, non-hygroscopic PVC, high resistance to impact, ribbed on circumference for flexibility.

2.7 STEEL CONDUIT ACCESSORIES

A. Sleeves Through Outside Walls: Cast iron, with end and intermediate integral flanges, and internal diameter larger than diameter of through-conduit. Length is to correspond to wall thickness. Space between sleeve and conduit is to be packed with oakum to within 50 mm of both faces of wall, remainder of sleeve packed with plastic compound or lead, held in place by heavy escutcheon plates bolted at both ends to flanged ends of sleeve. Alternatively, sleeves are to be O.Z/Gedney, Type WSK or other equal and approved, with cable or conduit bolted pressure sealing.

B. Supports and Hangers: Galvanized malleable cast iron straps or structural steel sections with hot dip galvanized bolts and nuts.

C. Expansion Joint for Embedded Steel Conduits - Type A: Watertight, flexible conduit with end fittings to receive fixed conduits. Length is to allow movement within range of joint and is not to be less than 20 times diameter of conduit. Conduit is to be covered with thick rubber tubing with 5 mm minimum gap all around tube. Bonding jumper with earth clamp is to electrically connect both sides of joint. Fitting is to be O.Z/Gedney, Type DX or other equal and approved.

D. Expansion Joint for Exposed Steel Conduits - Type B: Sleeve with fittings to permit telescoping of one conduit into sleeve. Movable conduit is to be fitted with watertight bushing. Joint is to be weatherproof,

of galvanized malleable iron or steel. Bonding jumper with earth clamp is to electrically connect both sides of joint. Expansion fitting is to be O.Z/Gedney, Type DXX or other equal and approved.

E. Expansion Joint for Exposed Steel Conduits - Type C: PVC sheathed flexible steel conduit terminating in pull boxes and securely fixed on each side of structural expansion joint. Bonding jumper is to electrically connect both sides of joint.

F. Tags: 50 mm diameter steel with indented lettering, rust inhibiting treatment and baked enamel finish.

2.8 WIRING AND CABLE TRUNKING

A. Components are to include wireway base, clip-on covers, couplings, end plates, wall flanges, panel to trunking rubber grommets, elbows, tees, adaptor plates and necessary hangers, supports and accessories.

B. Steel Trunking: To BS 4678 Part 1, galvanized sheet steel, minimum 1.5 mm thick, protected internally and externally with corrosion resistant finish such as zinc or cadmium with top coat of enamel.

C. PVC Trunking: high impact, heavy duty, self-extinguishing, rigid PVC with grooved double locking action of the clip-on cover. Design is to be approved by Engineer before ordering materials. Trunking is to be capable of receiving functional slot-in hangers and demountable separators to segregate wiring systems as needed.

D. Sizes: As required to accommodate number of conductors permitted by the Regulations and/or as shown on the Drawings.

2.9 WEATHERPROOF WIRING AND CABLE TRUNKING

A. Type: Hot-dip galvanized sheet steel trunking and cover, similar to Simplex, Power Center type or other equal and approved.

B. Construction: Trunking is to have outwardly turned flanges to receive cover, and internal sleeve coupling between sections, permitting cutting of trunking on site.

C. Gaskets: Neoprene bonded cork gaskets are to be fitted throughout, between any two attached surfaces.

D. Screws: Removable flanged covers are to be secured with galvanized steel holding screws.

2.10 SKIRTING TRUNKING

A. Type: Comprising wireway base, snap-on cover, couplings, end plates, wall flanges, elbows, tees, adapters, if required, and necessary clamps, hangers, supports and accessories. Wires and cables are to laid from front and held in place by clamps.

B. Steel Skirting Trunking: Sheet steel, 1.5 mm minimum thickness, protected internally and externally with corrosion resistant finish such as zinc or cadmium with top coat of enamel.

C. UPVC Skirting Trunking: High impact resistant, flame retardant UPVC (unplasticized polyvinyl chloride) to BS 476 Part 5 and Part 6.

D. Partitions: Trunking is to be partitioned continuously into compartments for separate circuits. Size of each compartment is to be determined by size and number of conductors housed, in accordance with the Regulations and/or as shown on the Drawings.

E. Dimensions: As shown on the Drawings and as required to accommodate specified wiring devices.

2.11 OUTLET BOXES, GENERAL

A. Surface or recessed boxes are to be suitable for type of related conduit or cable system. Shapes and sizes of boxes are to be of compatible standards as switches and socket outlets specified under Division 16 Section "Wiring Devices", and lighting fixtures selected and of various types and mounting methods required.

B. Unused openings in outlet boxes are to be closed with knock-out closers manufactured for the purpose.

C. Floor outlets and plates are to be water-tight and impact resistant.

2.12 METALLIC OUTLET BOXES

A. Recessed and Concealed Boxes: Galvanized pressed steel, with knock-outs for easy field installation. Special boxes are to be punched as required on Site.

B. Exposed Surface Mounted Boxes: Galvanized cast iron with threaded hubs.

C. Outdoor Surface or Recessed Boxes: Galvanized cast iron with threaded hubs and PVC gaskets to ensure water tightness and with stainless steel or non-ferrous, corrosion resistant screws.

D. Floor Boxes - Type A: Watertight, cast iron or cast metal alloy with corrosion resistant finish, adjustable mounting, standard duty, round or square, factory drilled and tapped for required conduit sizes, and with brass cover and flange with brushed finish free from markings other than required for mounting screws.

E. Floor Boxes - Type B: Non-standard size, flush floor mounted, cast metal alloy, with watertight neoprene gasketed and hinged cover, and with drilled and tapped conduit entries and adjustable mounting. Metal barriers are to separate services for power and low current.

F. Flame-Proof Boxes: Malleable iron or cast iron, with gas threaded hubs, special covers with silicon rubber gaskets, gas tight, and water-tight. Boxes are to comply with the Regulations for explosive areas.

2.13 MOULDED PLASTIC OUTLET BOXES

A. Type: Boxes and covers used with PVC conduit systems are to be heavy gauge pressure moulded plastic, minimum 2 mm thick, self-extinguishing, with softening point not less than 85 deg. C. Boxes are to have provision for securely terminating conduits and are to be manufacturer's standard for required application.

B. Fittings: Boxes are to have brass inset threads to receive cover screws and for mounting devices or accessories, push-fit brass earth terminals, and steel insert clips to provide additional support for pendants or for heat conduction. Neoprene gaskets are to be provided for weatherproof installations.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine surfaces to receive raceways and boxes for compliance with installation tolerances and other conditions affecting performance of raceway installation. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.2 CONDUIT, WIREWAYS, AND BOXES, GENERAL

A. Use: Unless otherwise specifically indicated all light and power circuits, communications, signal and low current systems wiring are to be drawn inside conduits or wireways up to the various electric power consuming equipment as shown on the Drawings.

B. Separate conduits and wireway installations are to be used for medium voltage cables, low voltage feeders and sub-feeders, normal light and power circuits, emergency light and power circuits and communication, signal and other low current systems wiring. Cables of different voltages are not to be mixed within the same conduit or wireway as per the regulations.

C. Boxes: Junction, pull, and splice boxes of ample capacity are to be provided as indicated or required. Boxes are to remain permanently accessible.

D. Exposed Outlet Boxes: Securely fasten to wall with machine screws to permanent inserts or lead anchors.

E. Recessed Outlet Boxes: Make neat openings, to the satisfaction of Engineer, allowing for thickness of finishings, and use extension rings if required. Repair damaged finishings to original condition before installation of fittings or plates.

F. Boxes Mounting Heights and Location: As specified under Division 16 Section "Wiring Devices".

G. Tools and accessories for forming and installing conduit and wireway systems are to be purpose made for the particular application and used in accordance with manufacturers' instructions.

H. Fixing: Conduits and wireway installations are to be concealed as much as possible.

I. Sizes of conduits and wireways, not shown on the Drawings, are to be selected in accordance with the Regulations and in relation to the number and size of conductors and the space factor as recommended by the regulations. Minimum size of conduit for all applications is to be 20 mm diameter, unless otherwise shown on the Drawings.

J. Mechanical Continuity: Conduits and wireways are to be effectively joined together and connected to electrical boxes, fittings and cabinets to provide firm mechanical assembly. Earthing jumpers are to be

installed on steel conduits where required to ensure effective electrical continuity irrespective of whether a separate protective earth conductor is required or not.

K. Metal conduits and enclosures are to be mechanically fastened, and to be connected to electrical boxes, fittings and cabinets to form low electrical resistance continuity and firm mechanical assembly.

L. Dissimilar Metals: Use of dissimilar metals is to be avoided throughout the system to eliminate possibility of electrolysis. Where dissimilar metals are in contact, treat surfaces with corrosion inhibiting compound before assembling.

M. Miscellaneous fittings such as reduces, chase nipples, 3 – piece unions, split couplings and plugs that have been specifically designed and manufactured for their particular application are to be installed as necessary.

N. Conduits are to be tested with a mandrel. Conduits that reject a mandrel are to be replaced. Restore conduit and surrounding surfaces to original condition.

3.3 CONDUITS AND WIREWAYS APPLICATIONS AND INSTALLATION, GENERAL

A. Conduits and wireways installations are to be as described below, unless otherwise shown on the drawings or described in the particular section of the Specification.

B. Rigid heavy gauge steel conduit is to be used for all exposed installations in the mechanical equipment rooms and electrical equipment rooms.. Use rigid steel conduit in areas classified as hazardous explosive area. Flexible conduit is not acceptable.

C. Light gauge steel conduit (EMT) is to be used for exposed and above false ceiling wiring installations used in conjunction with exit and escape route lighting.

D. Light gauge steel conduit (EMT) is to be used for exposed and above false ceiling wiring installations of fire alarm system..

E. Conduit termination in sheet metal enclosures is to be fastened by lockouts, and terminate with bushing. Install locknuts inside and outside enclosure.

F. Rigid heavy gauge PVC conduit is to be used for lighting and power circuits, low current, communication and signal system wiring, where embedded in concrete masonry earth, underfloor, except where otherwise shown on the Drawings or described in the particular section of the Specification.

G. Rigid heavy gauge PVC conduit is to be used above false ceilings for lighting and power circuits, low current, communication and signal system wiring, when the false ceiling is not used as return plenum – and in furred walls. Use flexible PVC conduits from outlet boxes to fixtures in conjunction with the use of PVC conduits.

H. Flexible conduit of same material as corresponding conduit system is to be used for connection to motors, vibrating and non-rigidly fixed equipment and to fixtures installed in false ceilings.

I. Flexible steel conduit is to be used in movable partitions and from outlet boxes to fixture over false ceilings when used as a return plenum. Conduits are to be liquid tight in damp areas.

J. Liquid-tight flexible steel galvanized conduit is to be used in one or more of the following conditions:

1. Exterior location.
2. Moist or humid atmospheres where condensate can be expected to accumulate.
3. Corrosive atmosphere.
4. Subjected to water spray or dripping oil, water or grease.

K. Exposure to Damage: Conduit considered to be subject to undue risk of damage by shock or corrosion is to be brought to the attention of the Engineer. Copper silicone alloy tubes may be used in corrosive atmospheres.

L. Crossing: Conduits are not to cross pipe shafts, vents or openings.

M. Clearances: Install conduits at least, 150 mm clear of and preferably above pipes of other non- electrical services. (Hot water pipes, etc.). Wherever possible, install horizontal conduit and wireways runs above water and steam piping.

N. Sleeves: Obtain approval for positioning sleeves where conduits pass through reinforces concrete. Additional opening may be allowed in finished slabs, but are to be drilled. Fix sleeves rigidly to maintain position and alignment during construction work.

O. Waterproof Construction: Conduits are not to cross waterproof construction unless permitted by Engineer. Specially designed and approved fittings are to be used.

P. Expansion Fittings: Provide in each conduit and wireways run every 30 meters, or wherever structural expansion joints are crossed.

Q. Make good all holes for conduits passing through walls, floors and ceilings with cement or similar fire-resisting material to full thickness.

R. Bends: Conduit runs between outlet and outlet, fitting and fitting or outlet and fitting are not to contain more than the equivalent of 2 quarter bends (180 degree total).

S. Bending is to be made without damaging conduit or tubing and without reducing internal diameter. Methods of field bending are to be approved.

T. Cut ends are to be reamed to remove burrs and sharp edges.

U. Conduits entering cold stores are to be made vapour tight, so that vapour from outside cannot enter conduit.

V. Draining: Arrange conduits so that condensed moisture can drain to screwed plug at lowest point.

W. Before wiring, conduits are to be swabbed through. Do not draw cables into any section of system until conduit and draw boxes are fixed in position, and the raceway installation is completed.

X. Capping: Conduits are to be properly capped until wiring conductors are drawn in.

Y. Conduit and fittings installed outdoors are to be watertight and highly resistant to corrosion. Use appropriate fittings, threaded and hubbed boxes, gaskets with screw on covers and the like.

Z. Terminations: Do not terminate or fasten rigid conduits to motor frame or base.

AA. Length and radius of flexible conduit used for motors and vibrating equipment are to permit bending of feeder cables without damage to conductor or insulation.

BB. Flexible conduit for slide rail mounted motor is to have sufficient slack to allow for movement of motor over entire slide rail length.

CC. Pulling Wire: Install 3 mm galvanized stranded steel wire or equivalent strength cord with wooden blocks fastened at ends, in empty service conduits (power, low current and signal).

DD. Standard elbows are to be used for conduit sizes over 40 mm. For smaller sizes, field bends may be used provided no damage occurs to conduit.

EE. Tags: Fit to conduits entering or leaving floors, walls or ceilings for identification of conduit and circuits. Tags are also to be placed at suitable intervals throughout the system.

3.4 STEEL CONDUITS

A. Termination: Conduit entering sheet metal enclosure or outlet boxes, when not terminated in a threaded hub, is to be securely held in place by two lock-nuts, placed inside and outside enclosure, and terminated with an insulating bushing.

B. Running Threads: Do not use running threads at joints and terminations, but use 3-piece unions or split couplings.

C. Additional threaded cuts on galvanized steel conduits are to be painted with zinc based coating resistant to corrosion.

D. Damage to protective coating of conduits is to be repaired to original degree of protection.

E. Outdoor Mounted Steel Conduit: Apply anti-corrosion coating of zinc-chromate based paint and two weather resistant finish coats of enamel, of approved colour, or other equal and approved coating.

F. Galvanized conduit run in screed is to be painted with heavy coat of emulsified bitumen.

G. Galvanized steel conduits buried in ground or placed in wet or damp locations are to be coated with two heavy coats of hot bitumen. Conduits are to be covered by at least 600 mm of earth if buried in planting soil and by 300 mm if under walkway.

H. Plugs: Use hardwood or threaded iron plugs for blanking ends of steel conduit not used.

3.5 PVC CONDUITS

A. Coupling of conduit and/or termination into spouted fittings are to be made watertight and permanent using special cement.

B. Termination: Connect conduits terminating in switchgear, fuseboards, trunking, adaptable boxes or other non-spouted enclosures etc. with smooth bore male PVC bushes and sockets.

C. Ends of conduit and conduit fittings are to be cleaned and jointed using PVC cement recommended by manufacturer.

D. Semi-Permanent Adhesive: Use in joints requiring expansion couplers.

E. Bends: Conduits not exceeding 25 mm diameter may be cold bent using bending springs. Conduits over 25 mm are to be hot bent by an approved method.

3.6 EMBEDDED CONDUITS

A. Conduits In Concrete Slabs: Place conduits parallel or at right angles to main reinforcing steel, between bottom reinforcing and top reinforcing steel. Fasten conduits to reinforcing steel by positive wire, fasteners at the proper distance from the concrete face. Embedded conduit diameter is not to exceed 1/3 of slab thickness. Special cases shall be referred to Engineer.

B. Conduits In Partitions or Side Walls: Horizontal or cross runs are to be avoided.

C. Pull-boxes are not to be used. If unavoidable, pull-boxes may be approved if located inconspicuously.

D. Conduits in floor of beds on grade: Encase in concrete, minimum thickness 50 mm or to thickness allowed by architectural detail.

E. PVC conduits in reinforced concrete structures are generally to be installed after placing reinforcement and before concreting, if protected against damage, or are to be placed in grooves formed in the concrete, if approved.

3.7 EXPOSED CONDUITS

A. Conduits on walls are to be run neatly, horizontally or vertically.

B. Supports: Use approved clamps, hangers or clips fastened by machine screws to expansion sleeves in inserts or to lead anchors.

C. Unless recommended by the manufacturer, spacing of clamps or clips for supporting steel conduits is not to be greater than:

Conduit Size	Maximum Spacing of Supports
mm	meters
20	3.00
25	3.60
32-38	4.25
50-63	5.00
75 and larger	6.00

D. Unless recommended by the manufacturer, spacing of clamps or clips for supporting PVC conduits is not to be greater than:

	Conduit Size mm	Maximum Spacing of Supports metres	
		Conductors Rated 60 deg.C and below	Conductors Rated more than 60 deg.C
1.	20	1.25	0.60
2.	25-50	1.50	0.75
3.	63-75	1.80	0.90
4.	90-125	2.00	1.00
5.	150	2.50	1.25

E. Bends and Fittings: Firmly fasten conduit at each side of bends and within 900 mm of each outlet box, junction box, cabinet or fitting.

F. Outlets: Do not run more than the permissible numbers of conduits to any surface wall outlet.

G. Exposed conduit work is to be installed so as not to interfere with ceiling inserts, lights or ventilation ducts or outlets.

3.8 CABLE TRUNKING

A. Installation: Secure trunking of all sizes at intervals not exceeding 1200 mm. Joints are not to overhang a fixing by more than 500 mm.

B. Trunking passing through walls and ceilings is to have the cover fixed solidly for 25 mm either side of walls and for 150 mm either side of floors and ceilings.

C. Vertical sections of trunking over 900 mm long are to have staggered insulated tie-off studs to support weight of cables.

D. Cabling Provisions: Separation of power, low current and control circuits is to be by two channel trunking or by barriers inserted in trunking before installation of cables. Cable retaining straps are to be provided at not more than 600 mm centers. Openings in front of trunking are to facilitate drawing-in cables.

E. Coupling: Trunking parts are to be mechanically and electrically coupled without causing abrasion to wiring.

F. Earthing: Do not use metal trunking as earth continuity conductor. Provide protective conductor in accordance with Division 16 Section "Grounding and Bonding" of the Specification.

3.9 PROTECTION

A. Provide final protection and maintain conditions, in a manner acceptable to manufacturer and Installer that ensure coatings and finishes are without damage or deterioration at the time of Substantial Completion.

1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
2. Repair damage to PVC or paint finishes with matching touchup coating recommended by manufacturer.

3.10 CLEANING

A. On completion of installation, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finish, including chips, scratches, and abrasions.

END OF SECTION 1003

SECTION 1004 - CABLE TRAYS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Conditions of Contract, apply to this Section.

1.2 SUMMARY

A. This Section includes cable trays, cable ladders and related installations and accessories necessary to support and protect cables, feeders, sub-feeders, branch circuit wiring and wiring of low current systems, communications and signal cables.

B. Related Sections include the following:

1. Division 100 Section "Basic Electrical Materials and Methods" for cable tray / ladder supports not specified in this Section.

1.3 SUBMITTALS

A. Technical Data: Submit data for approval including, but not limited to, the following:

1. Manufacturers' catalogues with specifications of cable trays / ladders and related accessories.
2. Samples of each type of tray / ladder and accessory.

B. Shop and Construction Drawings: Submit drawings for approval including, but not limited to, the following:

1. Detail fabrication and installation of cable tray / ladder, including plans, elevations, and sections of components and attachments to other construction elements. Designate components and accessories, including clamps, brackets, hanger rods, splice-plate connectors, expansion-joint assemblies, straight lengths, fittings and earthing connections.

C. Coordination Drawings: Include floor plans and sections drawn to scale. Include scaled cable tray / ladder layout and relationships between components and adjacent structural and mechanical elements.

D. Design Calculations: Verify loading capacities for supports.

E. Maintenance Data: For cable trays to include in the maintenance manuals specified in Division 1.

1.4 QUALITY ASSURANCE

A. Source Limitations: Obtain cable tray components through one source from a single manufacturer.

B. Comply with related BS Standards.

1.5 PROJECT CONDITIONS

A. Existing Utilities: Do not interrupt utilities serving facilities occupied by the Employer or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated.

1. Notify Engineer not less than 2 days in advance of proposed utility interruptions.
2. Do not proceed with utility interruptions without Engineer's written permission.

1.6 COORDINATION

A. Coordinate layout and installation of cable tray / ladder with other installations.

1. Revise locations and elevations from those indicated as required to suit field conditions and as approved by the Engineer.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Approved Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

1. Saudi electric industries Co. (Saudi Arabia)
2. El-Sweedy industries (Egypt)
3. NTT (Egypt)

2.2 CABLE TRAYS AND LADDERS

A. Components: To include cable trays or ladders (as shown on the Drawings), bends, elbows, tees, couplings and plates, rubber grommets, hangers, bracket supports and other system accessories required for safety and protection of the cable installations.

B. Trays: Provide to carry the maximum load of cables with a factor of safety 300%.

C. Trays: Heavy gauge perforated sheet steel, hot-dip galvanized after manufacture, minimum 1.5 mm thick, with sides not less than 45 mm deep, and as shown on drawings. Fittings are to be same material as tray. Covers, where shown on the Drawings, are to be minimum 1.0 mm thick galvanized sheet steel, Snap-On or bolt type, forming a rigid assembly with the tray.

D. Ladders: to be hot-dip galvanized after manufacture, fabricated from 2mm mild carbon steel. Ladder side channels are to be minimum 127 x 32 mm, strengthened by reinforcing inserts for torsional rigidity. Rungs are to be slotted to take cable cleats or ties and conduit clamps. Rungs are to be minimum 50 x 25 mm channels, spaced at 300 mm centers.

E. Galvanizing to be in accordance with BS 729 (335 g/m2), applied after fabrication.

F. Bolts and Screws: Cadmium plated or electrolytically galvanized.

G. Coating applied to cable tray or cable ladder is to be applied after priming coat.

H. Sizes: Trays and ladders are to be standard metric sizes, 150, 300,450 and 600 mm wide. Or as shown on the drawings. Size of tray or ladder is to be determined by number and sizes of cables in accordance with the Regulations and / or as shown on the Drawings. Tray or ladder is to have strength and rigidity to provide support for cables contained within. Deflection between supports is not to exceed 1/350 under full loading capacity.

I. Earthing connector for plastic coated trays or ladders is to be provided on each coupling between adjacent sections.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install cable tray / ladder level and plumb according to manufacturer's written instructions, Coordination Drawings, original design, and referenced standards.

B. Each run is to be completed before installation of cables.

C. Remove burrs and sharp edges from cable trays / ladders. Fix trays / ladders using approved suspension rods or steel angle brackets at spacing not exceeding 1.5 m and generally as shown on the Drawings.

D. Cables: Secure to tray / ladder with purpose made straps or saddles and arrange in one layer only, evenly spaced, or as shown on the Drawings, with minimum spacing of one diameter of the larger of the two adjacent cables or of a trefoil formation of single core cable circuit.

E. Fasten cable tray / ladder supports securely to building structure as specified in Division 16 Section "Basic Electrical Materials and Methods," unless otherwise indicated.

1. Design supports, including fastenings to the structure, to carry the greater of the calculated load multiplied by a safety factor of 4. Submit calculations for approval.

F. Make connections to equipment with flanged fittings fastened to cable tray / ladder and to equipment. Support cable tray / ladder independently of fittings. Do not carry weight of cable tray / ladder on equipment enclosure.

G. Install expansion connectors where cable tray / ladder crosses a building expansion joint and in cable tray / ladder runs that exceed 27 m. Make changes in direction and elevation using standard fittings.

H. Make cable tray / ladder connections using standard fittings.

I. Locate cable tray / ladder above piping, unless accessibility to cable tray / ladder is required or unless otherwise indicated.

J. Seal penetrations through fire and smoke barriers according to Division 7 Section "Through-Penetration Firestop Systems."

K. Sleeves for Future Cables: Install capped sleeves for future cables through fire stopping-sealed cable tray / ladder penetrations of fire and smoke barriers.

L. Workspace: Install cable trays / ladders with sufficient space to permit access for installing cables. Minimum clearance of 250 mm is to be maintained between top of tray / ladder and ceiling, beams and other services and between tray / ladders in multi-tier formation.

M. Barriers: Where tray / ladders carry conductors of different systems, such as power, communications and data processing, or different insulation levels, such as 600V, 5000V, and 20, 000 V use separate cable tray / ladders. In case of absolute necessity, install insulating barriers to separate the systems after obtaining the Engineer's approval.

N. Install covers after installation of cable is completed.

3.2 CONNECTIONS

A. Ground cable trays / ladders according to manufacturer's instructions.

1. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values.

3.3 WARNING SIGNS

A. After installation of cable trays / ladders is completed, install warning signs in visible locations on or near cable trays / ladders.

3.4 FIELD QUALITY CONTROL

A. Grounding: Test cable trays / ladders to ensure electrical continuity of bonding and grounding connections.

B. Grounding: Do not use metal trays / ladders as earth continuity conductor. Connect trays / ladders by flexible tinned copper straps to nearest bare earthing conductor and at maximum 30-m spacing.

C. Anchorage: Test pullout resistance for toggle bolts and powder-driven threaded studs for each type and size of anchorage material.

1. Furnish equipment, including jacks, jigs, fixtures, and calibrated indicating scales, required for reliable testing.
2. Obtain Engineer's approval before transmitting loads to the structure. Test to 90 percent of rated proof load for fastener.

D. Replace malfunctioning units.

3.5 CLEANING

A. On completion of cable tray / ladder installation, including fittings, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finishes, including chips, scratches, and abrasions.

3.6 PROTECTION

A. Provide final protection and maintain conditions, in a manner acceptable to manufacturer and Installer that ensure cable tray / ladder is without damage or deterioration at the time of Substantial Completion.

1. Repair damage to galvanized finishes with zinc-rich paint recommended by cable tray / ladder manufacturer.
2. Repair damage to PVC or paint finishes with matching touchup coating recommended by cable tray / ladder manufacturer.

END OF SECTION 1004

SECTION 1005 - WIRING DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Conditions of Contract , apply to this Section.

1.2 SUMMARY

A. This Section includes wiring devices, lighting switches, socket outlets, cord outlets, automatic and manual lighting control equipment, dimmers, outlet boxes and plates, etc.

B. Components are to be standard manufactured items, uniform and modular, complying with one set of approved Standards.

C. Related Sections include the following:

1. Division 100 Section "Basic Electrical Materials and Methods".
2. Division 100 Section "Raceways and Boxes" for boxes.

1.3 SUBMITTALS

A. Technical Data: Submit data for approval, including catalogues, detailed literature, manufacturer's name, catalogue number, rating, specification, overall dimensions and special features, as applicable for each item.

B. Shop and Construction Drawings: Submit drawings for approval including, but not limited to, the following:

1. Exact indication of position of each item and outlet box and fitting on layout drawings, with box and equipment types and sizes.
2. Installation details of special devices including fans etc.
3. Wiring diagrams of special items.

C. Samples: Submit samples of each type of device for approval, unless otherwise agreed in writing by the Engineer.

D. Maintenance Data: For materials and products to include in maintenance manuals.

1.4 QUALITY ASSURANCE

A. Comply with related Standards.

1.5 EXTRA MATERIALS

A. Furnish 2 % (with minimum of one each) extra materials for all products that match those installed and that are packaged with protective covering for storage and identified with labels describing contents. Deliver extra materials to Employer.

PART 2 - PRODUCTS

2.1 PLATES, GENERALLY

A. Blank Plates: Blank plates are to be installed on outlet boxes, specified under Division 16 Section "Raceways and Boxes", on which no apparatus is installed or where apparatus installed does not have suitable cover for box. Blank plates for wall outlets are to be attached by a bridge with slots for horizontal and vertical adjustment.

B. Floor outlets and plates are to be watertight and impact resistant.

2.2 PLATES AND CORD-OUTLETS

A. Design: Square, rectangular or round designed to cover outlet box and to closely fit electrical device, and with polished chromium plated recessed head fixing screws. Combination plates are to be used for grouped outlets and devices.

B. Cord extension plates are to have threaded cord grip bushings of same material and finish as plates.

C. Plastic Plates: Heavy gauge, break resistant, pressure molded plastic, white color, for general use in service areas and toilets.

1. Man: MK
2. Ref: Logic plus

D. Stainless Steel Plates: Heavy gauge, pressed stainless steel, satin finish, minimum 1 mm thick, for use in public areas.

1. Man: MK
2. Ref: Chrome plus

E. Stainless Steel Plates: Heavy gauge, pressed stainless steel, satin finish, minimum 1 mm thick, for use in plant areas.

1. Man: MK
2. Ref: Metal clad plus

F. Cable/cord outlet (electric outlet) is to be used for up to 45 A, 250 V rating for connection of power/control cable of fixed appliances. Plate is to have threaded cord grip to anchor cable securely to cover. Box is to include fixed terminal block and cable clamp for termination of cable/cord within.

G. Lighting outlet is to consist of outlet box, coverplate, and necessary accessories ready for connection to lighting fixture.

2.3 SWITCHES

A. Generally: Quick-make, quick-break type with silver alloy contacts in arc resisting molded base, with toggle, rocker or push-button as specified, for inductive or resistive loads up to full rated capacity, and arranged for side and/or back connection.

B. Types: Single, two-way or intermediate, single pole or double pole, as shown on the Drawings.

C. General Lighting Switch (S1): Recessed 10 A, 240 V a.c., rocker operated, grid-switch with plastic plate, for service areas installations.

1. Man: MK
2. Ref: Logic plus

D. General lighting switch (S2): similar to type S1, but with satin stainless steel switch finish and plate for public areas installation.

1. Man: MK
2. Ref: Chromo plus

E. General Lighting Switch (S3): surface mounted with steel box.. Similar to type S1, but with stain stainless steel switch finish and satin stainless steel plate for plant areas installation.

1. Man: MK
2. Ref: Metal clad plus

F. Weatherproof Switch (S4): 10 A, 250 V, for installation outdoors and in wet areas, with weatherproof plate, weatherproof outlet box, on/off indication, IP 56 enclosure.

1. Man: MK
2. Ref: Master seal

G. Double Pole Switch (S5): Rated 20Aor as shown on the Drawings, 250 V a.c., tumbler operated, to BS 3676, with stainless steel or molded plastic plate (as required in application area), marked (etched) with equipment controlled (i.e. cooker, air conditioner, water heater) and with red neon pilot light for "on" position. Switch is to be mounted to flush or surface box, as required or as shown on the Drawings, and provided with cord outlet and cord extension to equipment controlled.

1. Man: MK
2. Ref: K14336 BSS, K14336 POC or K5230 WHI

H. Manual Switch (S6): 2 pole, for fractional single-phase motors and appliances, to interrupt motor and induction loads, rated 25 A at 240 V a.c., toggle operated, with positive indication of on/off position of contacts.

1. Man: Square D
2. Ref: Type KG

I. Remote Lighting Control Panel for Contactor Control: Multiple two ways momentary on/off push switch assembly, with an 'on' pilot light for each circuit controlled (remote contactor). Panel and box are to be sheet steel construction, with see-through steel-framed acrylic door and trim, handle and lock. Enclosure protection IP 42 to IEC 144 for indoor installation and IP 55 for outdoor installation.

J. Weatherproof triple pole switch (S7): Rated 45A, with tough polycarbonate of IP56 enclosure, neutral and earth terminals fitted as standard, used with electric motor driven equipment.

1. Man: MK
2. Ref: Safety switch

K. Triple pole switch (S8): Rated 20A, contact with double break silver plate for each pole, IP20.

1. Man: Schyller
2. Ref.: IM 30 series.

2.4 SOCKET OUTLETS

A. Generally: To have injection molded plastic base with self-adjusting, non-expanding contacts to prevent permanent distortion, arranged for side and/or back connection and with screw terminals accepting at least three parallel branch-circuit wires.

B. Types: General-purpose socket outlets are to conform to standard British practice.

C. Duplex sockets are to be mounted in parallel under one common plate with break-off feature for two-circuit connection.

D. Weatherproof socket outlets are to be any of the types indicated, enclosed in surface mounted cast metal box and with cover comprising spring-retained gasket hinged flap. Enclosure is to be pre-designed box and cover for type of socket outlet specified.

E. Standard British Socket Outlet - Type R01 (220 V SERVICE): To BS 1363, polarized, grounding type, with three rectangular pin-holes (two poles and earth), rated 16 A, 250 V, switched, with robust shutter mechanism operated by earth pin with plastic plate, used in service areas.

1. Man: M.K.
2. Ref: Logic plus

F. Standard British Socket Outlet - Type R02: Similar to type R01. But with satin stainless steel plate for public areas installation.

1. Man: M.K.
2. Ref: Chroma plus

G. Standard British Socket Outlet - Type R03: Surface mounted similar to type R01 but with satin stainless steel plate and steel box for plant areas installation.

1. Man: M.K.
2. Ref: Metal clad plus

H. Weatherproof Socket Outlet - Type R05 (220 V SERVICE): 13 A, 250 V, 2 pole plus earth, to BS 1363, enclosed in surface mounted cast-metal box and with cover comprising spring- retained gasket hinged flap.

1. Man: MK
2. Ref: Master seal

I. Power Socket - Type R07: Single outlet, single phase, three wire, 32 A, 250 V, polarized with L-shaped earth contact, splash proof molded cast metal plate and matching plug.

1. Man: MK
2. Ref: Commando “K9865”

J. Power Socket Outlet - Type R09 (380 V SERVICE): Single outlet, 3P+E, 3 phase, polarized, earthing type, rated 32 A, 380/415 V, to BS 4343 and IEC 309, with splash proof cast metal box and hinged spring-return plate, and with matching plug 3P+E.

1. Man: MK
2. Ref: Commando “K9435”

2.5 PLUGS

A. Type: Compatible with type of socket outlet specified, break resistant, of impact resistant molded insulating material (separable construction), with solid brass pins and cord grip and of shape Providing Easy Hand-Grip for Removal.

B. Quantity: Supply number equal to 20% of total number of each type of socket outlet supplied.

C. Fuses for standard British type sockets are to be standard 13 A cartridge fuses fitted in plug.

2.6 SPECIAL DEVICES

A. Lighting Contactors

1. Type: Double pole for single phase and neutral circuits, and triple pole for three phase circuits, mechanically held, electrically operated, rated 500 V, of current ratings shown on the Drawings, and complying with IEC-158-1 category AC 2 and AC 3.

2. Contacts: Copper alloy, with silver cadmium alloy double break contacts designed for switching inductive ballast loads and switching of tungsten lamp loads.

3. Auxiliary Contacts: As required to provide specified interlocks and signals as shown on the Drawings, or required by the Specification, with one N.O. and one N.C. spare contacts.

4. Enclosure: Unless forming part of system housed in sheet steel panel, contactor is to be provided with IP 42 enclosure for indoor use or IP 65 enclosure for outdoor use.

5. Control: Each contactor whether part of a system or separately enclosed is to have on/off pilot lights and set of on/off push buttons mounted on cover.

B. Photoelectric Cells

1. Photoelectric Cells: Omni directional cadmium sulfide, hermetically sealed, with 2:1 on/off adjustment possible by moving light level selector, set to operate at illuminance levels shown on the Drawings. Unit is to include timer giving 3-minute delay to prevent false switching. Temperature range is to be -10 deg. C to +80 deg. C.

2. Safety: Control is to be designed such that in case of failure, unit fails in the on position.

3. Contacts are to close or open as illumination level increases to set level with respect to requirements shown on the Drawings.

4. Enclosure: Heavy duty cast metal, with translucent dome of 'Lexan' (by G.E.) or other equal and approved, to protect against high ultra violet rays, and 180 deg. swivel base and 16 mm threaded conduit mounting. Enclosure is to be weatherproof and protected against high winds and storms.

C. Remote Lighting Relay Control System

1. Remote Lighting Relay Panel (RLRP): Comprise set of heavy duty long life service relays, rated 20 A, 380/220 V a.c. for switching tungsten or fluorescent lighting loads, SPST maintained (mechanically latched), with 24 V a.c. split-coil (1/2-on and 1/2-off) for control by remote push button on/off switches, via 24 V control transformer.

2. Push Button Switch (LS): SPDT, momentary contact, normally open switch with pilot light and red jewel Lens, Rated 3 A, 25 V A.C.

3. Master Selector Switch Panel (MSSP): Comprise set of push button switches type (LS), assembled in one unit comprising box and cover, with individual switch per circuit controlled, and one master switch for all-circuit control.

4. System is to allow local and remote centralized switching of group of lighting circuits and from any number of individual points. System is to use low voltage (low current) control circuitry to operate relay switches on branch circuits.

5. Manufacturers: System is to be by G.E. Remote Control Products or other equal and approved.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Locations: Drawings generally show approximate locations of outlets and equipment. Exact locations are to be determined from interior finishing and detail drawings. Any condition that would place an outlet in an unsuitable location is to be referred to the Engineer. Locate switches at strike sides of doors, whether shown on the Drawings or not. In locating outlets allow for overhead pipes, ducts, variations in arrangement, thickness of finishing, window trim, paneling and other engineering features.

B. Mounting heights for outlet boxes and similar equipment are to be uniform within the same or similar areas. Mounting is to be as shown on the Drawings or as approved by Engineer. Unless otherwise shown or instructed, mount lighting switches and socket outlets generally at 1200 mm and 300 mm from finished

floor level respectively. Mount switches with long dimension vertical and operating handle, if of the toggle type, up when in the on position.

C. Additional outlets to those shown on the Drawings are to be provided as required by equipment manufacturers for control or other wiring.

D. Recessed Outlet Boxes: Make neat openings, to the satisfaction of the Engineer, allowing for thickness of finishing, and use extension rings if required. Repair damaged finishing to original condition before installation of fittings or plates.

E. Appearance: Install exposed boxes and plates plumb, square and parallel to finished wall surface. Exposed plates covering recessed boxes are to rest neatly on wall surface without gaps, and fully covering the box.

F. Grouped Outlets: Arrange neatly so that use of fittings is convenient and clear.

G. Waterproof and Explosion-Proof Fittings: Follow manufacturer's instructions for installation and connection to conduit system to fully achieve required degree of protection.

H. Damaged Fittings: Reject damaged fittings or plates with damaged finish. Protect fittings and plates against damage after installation and until handed over.

3.2 IDENTIFICATION

A. Comply with Division 16 Section "Basic Electrical Materials and Methods."

1. Switches: Where three or more switches are ganged, and elsewhere as indicated, identify each switch with approved legend engraved on wall plate.
2. Receptacles: Identify panel board and circuit number from which served. Use machine-printed, pressure-sensitive, abrasion-resistant label tape on face of plate and durable wire markers or tags within outlet boxes.

3.3 CONNECTIONS

A. Single pole switches are to switch the phase wire. Do not run neutral wire through switches having neutral shunt or bridge.

B. Exposed Outlet Boxes: Securely fasten to wall with machine screws to permanent inserts or lead anchors.

C. Connection Of Appliances:

1. Where appliance is designed to adapt directly to outlet box, extend electrical wiring to incoming terminals inside appliance.
2. Where appliance is not designed to adapt to outlet box, install the connecting wiring in flexible conduit firmly fixed to outlet box cover plate and to terminal box on appliance.

D. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values.

3.4 FIELD QUALITY CONTROL

A. Visual Inspection: Fittings and equipment are to be inspected for fixing and workmanship.

B. Megger tests are to include switch and socket outlet tests together with insulation resistance of wiring installations.

C. Operation: Devices are to be tested for operation and are to perform as intended at full load without any signs of heating.

D. Equipment is to be insulation tested and observed, under full-load for not less than 3 days operation, with respect to undue heating and performance in general.

3.5 CLEANING

A. Internally clean devices, device outlet boxes, and enclosures. Replace stained or improperly painted wall plates or devices.

END OF SECTION 1005

SECTION 1006 - POWER FACTOR CORRECTION CAPACITORS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Conditions of Contract , apply to this Section.

1.2 SUMMARY

A. This Section includes automatic power factor correction equipment rated 600 V and less.

B. Related Sections include the following:

1. Division 100 Section "Basic Electrical Materials and Methods".

1.3 SUBMITTALS

A. Product Data: For each type of product indicated. Include dimensions; shipping, installed, and operating weights of multiple capacitor cells or elements; and data on features, ratings, and performance.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, method of field assembly, components, and location and size of each field connection. Show access and workspace requirements and required clearances.

1. Wiring Diagrams: Detail internal and interconnecting wiring and differentiate between manufacturer-installed and field-installed wiring.

C. Factory Test Reports: Evidence of product's compliance with specified requirements.

D. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.

E. Maintenance Data: For equipment to include in maintenance manuals specified in Division 1. Include the following:

1. Lists of spare parts and replacement components recommended for storage at Project site.
2. Detailed instructions covering operation under both normal and abnormal conditions.

1.4 QUALITY ASSURANCE

A. Comply with IEEE 18 and NEMA CP 1.

1.5 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents. Deliver extra materials to Employer.

1. Fuses: one for every step, as shown on drawings, of each type and rating, but not less than 3 of each.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Approved Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

1. Power Factor Correction Capacitors:

a. ABB Control, Inc.
b. General Electric Co.; Business Information Center.

c. Square D Group Schneider.

2. Automatic Power Factor Correction Units:

a. ABB Control, Inc.
b. General Electric Co.; Business Information Center.
c. Square D Groupe Schneider.

2.2 CAPACITORS, GENERAL

A. Construction: Multiple capacitor cells or elements, factory wired in three-phase groups and mounted in metal enclosures.

B. Capacitor Cells: Dry, metallized-dielectric, self-healing type. Each cell shall be encapsulated in thermosetting resin inside plastic container.

C. Cell Rupture Protection: Pressure-sensitive circuit interrupter for each cell.

D. Capacitor-Bank Fuses: Current limiting, non-interchangeable type; factory installed in each phase and located within the equipment enclosure. Features include the following:

1. Interrupting Capacity: 200,000 A, minimum.
2. Fuse Ratings and Characteristics: As recommended by capacitor manufacturer.
3. Neon Indicator Lamp for Each Fuse: Connect to illuminate when fuse has opened, but is still in place, and locate so it is visible from outside the enclosure.

E. Discharge Resistors: Factory installed and wired.

F. Enclosure: NEMA 250, steel or aluminum, arranged to contain the fluid leakage from capacitor cells; factory equipped with mounting brackets suitable for type of mounting indicated.

1. Indoor Enclosures: NEMA 250, Type 12 or as indicated.
2. Outdoor Enclosures: NEMA 250, Type 4, equipped with watertight conduit connections.

2.3 FIXED CAPACITORS

A. Description: Integrally fused, unless otherwise indicated.

B. Internal Wiring: Factory wired, ready for field connection to external circuits at a single set of pressure terminals.

2.4 AUTOMATIC POWER FACTOR CORRECTION UNITS

A. Comply with NEMA ICS 2.

B. Description: Capacitor banks, contactors, controls, and accessories factory installed in independent enclosures. Units include a separately mounted current transformer to sense current in the power circuit being corrected and to provide input to unit controls.

C. Performance Requirements: Controls permit selection of a target power factor, adjustable to any value between unity and 0.80 lagging. Controls continuously sense the power factor on circuits being corrected and, when the power factor differs from the target setting for more than 10 seconds, operate a contractor to switch a capacitor bank into or out of the circuit. Contactors are opened or closed as required to bring the corrected circuit power factor closer to the target setting. Switch only one capacitor bank at a time.

D. Controls: Solid-state, microprocessor-based controls, including the following:

1. Under voltage relay that interrupts capacitor switching and disconnects capacitors for power supply interruptions longer than 15 minutes.
2. "Advance" and "Retard" push buttons on the control panel to permit manually controlled capacitor-bank switching.

E. Contactors: Three pole; rated for the repetitive high-inrush-switching duty in the capacitor application.

F. Buses: Plated copper.

G. Fuses for Protection of Capacitor Banks: Rated to protect contactor, interconnecting wiring, and capacitors.

H. Inductors: Air-core-type, connected in capacitor circuits; rated to limit switching surges to within contactor ratings.

I. Mechanical Bracing for Current-Carrying Parts: Adequate to withstand the maximum fault current to which they may be exposed.

J. Identification of Energized Capacitor Banks: LED indicating lamps on front panel.

K. Enclosure Access: Hinged door with hand-operated catch. Door is interlocked with controls or main circuit breaker to de-energize capacitors when door is opened.

L. Local Display: LED or liquid-crystal digital type, mounted in door of enclosure.

1. Indicated target and actual power factors.
2. Accuracy: Plus or minus 1 percent.
3. Mounting: Flush or semi flush in unit door.

M. Current Transformer: Type, configuration, and ratio to suit sensing and mounting conditions.

N. Main Circuit Breaker: Operable from outside the enclosure to disconnect the unit.

1. Operating handle can be padlocked.

O. Remote Monitoring Components: Sensors, associated communication modules, and network interface units, matched to and compatible with GSM. Communication module transmits data to remote monitoring devices. Data includes actual corrected power factor and number of capacitor steps connected.

2.5 FACTORY FINISH

A. Manufacturer's standard enamel over corrosion-resistant treatment or primer coat.

2.6 SOURCE QUALITY CONTROL

A. Factory test power factor correction equipment before shipment. Comply with NEMA CP 1. Include the following:

1. Routine capacitor production tests, including short-time overvoltage, capacitance, leak, and dissipation-factor tests.
2. Functional test of all operations, controls, indicators, sensors, and protective devices.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install freestanding equipment on concrete bases. Cast-in-place concrete is specified in Division 3.

B. Maintain minimum workspace according to manufacturer's written instructions.

C. Connect remote monitoring communication module to electrical power monitoring and control data network through appropriate network interface unit.

3.2 IDENTIFICATION

A. Identify components according to Division 16 Section "Basic Electrical Materials and Methods."

3.3 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified independent testing agency to perform field quality-control testing.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect automatic power factor correction equipment installation and connections. Report results in writing. Include the following:

1. Operational Test: After electrical circuits have been energized, connect and observe units to confirm proper operation.
2. Replace damaged and malfunctioning controls and equipment.

C. Inspection: Perform external and internal inspections of capacitor equipment for damage and for compliance with the Contract Documents and manufacturer's documentation. Check electrical and mechanical bolted connections for required torquing.

D. Testing: Perform the following and certify compliance with test parameters:

1. Test insulation resistance between capacitor terminals and case. Follow manufacturer's written instructions or those below:

    a. Use test voltages 500 V minimum, for equipment rated 250 V and less, and 1000 V minimum, for equipment rated more than 250 V.
    b. Apply test voltage for 60 seconds.
    c. Investigate, report, and resolve insulation resistance less than that stated by manufacturer's literature or less than allowable 25 mega ohms for equipment rated 250 V and less and 100 mega ohms for equipment rated more than 250 V.

2. Measure capacitance of pole-to-pole capacitor combinations and compare with manufacturer's published values. Report readings, and investigate and resolve discrepancies more than 10 percent of manufacturer's nominal values.
3. Energize circuits and demonstrate electrical operating features of automatic power factor correction units according to manufacturer's written instructions.

E. Correct deficiencies shown by inspections and tests on site where possible, and retest; otherwise, remove and replace with new units and retest.

F. Report of Tests and Inspections: Written record including adjustment settings.

3.4 ADJUSTING

A. Adjust for optimum automatic power factor correction.

3.5 CLEANING

A. After completing equipment installation, inspect unit components. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish.

B. Clean components internally, on completion of installation, according to manufacturer's written instructions.

3.6 DEMONSTRATION

A. Train Employer's maintenance personnel to adjust, operate, and maintain the system installation.

END OF SECTION 1006

SECTION 1007 - SWITCHBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Conditions of Contract, apply to this Section.

1.2 SUMMARY

A. This Section includes Main Distribution Board(s) work for low voltage (LV) distribution, ancillary mounting frames, fittings, cable termination accessories and supports.

B. Connection to GSM system, including interface elements such as relays, transducers, etc. And /or shown on the Drawings or Specification.

C. Requirements of the following Sections apply to this Section:

1. Division 100 Section "Basic Electrical Materials and Methods".
2. Division 100 Section "Grounding and Bonding".
3. Division 100 Section "Conductors and Cables".

1.3 DEFINITIONS

A. MDB: Main distribution board.

B. CT: Current Transformer.

C. VT: Voltage Transformer.

D. EMI: Electromagnetic interference.

E. RMS: Root mean square.

F. The following terms used on the Drawings and in the Specification are synonymous and may be used interchangeably: "Switchboard" and "Main Distribution Board".

1.4 SUBMITTALS

A. Product Data: Submit for approval detailed description of main distribution boards including all components supported by manufacturer’s catalogues, indicating compliance with the Standards specified under "Quality Assurance" Article, equipment characteristics, details of construction, operating data, dimensions and weights etc. Give details of miscellaneous items including incoming and outgoing feeder terminal arrangement, connections at busbars, isolating, earthing, interlocks, control devices, indicating and metering instruments etc. Boards are to be factory assembled and tested and shipped as complete package (s).

B. Shop and Construction Drawings: Submit drawings for approval including, but not limited to, the following:

1. Plans and elevations with indication of built-on equipment, exact dimensions, and weights.

2. Arrangement of boards inside rooms allocated, indicating spaces and clearances.
3. Arrangement of equipment inside board.
4. One-line diagram of power system showing current ratings of switchgear and bus bars and types and locations of protective gear (relays, instruments, CTs, VTs etc.)
5. Schematics and wiring diagrams of control circuits. Differentiate between manufacturer-installed and field-installed wiring.
6. Foundation details and grouting holes installation details.
7. Arrangement of incoming and outgoing feeders, terminal fittings, instruments, busbar connections etc.
8. Utility Company's metering provisions with indication of approval by utility company.
9. Mimic-bus diagram.

C. Technical Literature: Submit the following for approval prior to placing orders for equipment manufacture:

1. Schedule of circuit breakers application, indicating type, range, features and characteristics, short-circuit ratings, time-current curves etc.
2. Method of setting of protective devices for overload, short-circuit and earth-fault currents as coordinated with upstream and downstream systems based on specific coordination curves of protective devices used and specific calculated prospective short-circuit currents at various points.
3. Test methods on site and references, including testing equipment for microprocessor controlled trip units.

D. Samples: Representative portion of mimic bus with specified finish, for color selection.

E. Qualification Data: For firms and persons specified in "Quality Assurance" Article. Provide evidence of applicable registration or certification.

F. Tests and Certificates: Submit complete certified manufacturer's type and routine test records, in accordance with the Standards specified in "Quality assurance" Article.

G. Field Test Reports: Submit written test reports and include the following:

1. Test procedures used.
2. Test results that comply with requirements.
3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

H. Manufacturer's field service report.

I. Updated mimic-bus diagram reflecting field changes after final main distribution board load connections have been made, for record.

J. Maintenance Data: For main distribution boards and components to include in maintenance manuals include the following:

1. Routine maintenance requirements for main distribution boards and all installed components.
2. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
3. Time-current curves, including selectable ranges for each type of overcurrent protective device.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: Engage an experienced installer with minimum five years of successful installation experience on projects utilizing main distribution boards units similar to those required for this project.

B. Manufacturer Qualification: A firm regularly engaged in the manufacture of main distribution boards, of types, sizes, and capacities required, and whose products have been in satisfactory use in similar service for not less than five years.

C. Codes and Standards: Comply with the latest issue of:

1. IEC 60439-1: Low Voltage Switchgear and Control Gear Assemblies: Type-Tested and Partially Type-Tested Assemblies.
2. IEC 60947-2: Low Voltage Switchgear and Control Gear: Circuit Breakers.
3. Relevant IEC Standard for other components, where not otherwise specified.
4. IEC 600831-1 & 2 for power factor correction capacitors.

D. Compliance with Local Requirements: Comply with applicable local regulations/code requirements of authorities having jurisdiction. These will have precedence over other codes/standards nominated for the project, unless otherwise approved in writing.

E. Product Selection for Restricted Space: Drawings indicate maximum dimensions for main distribution boards, including clearances between main distribution boards, and adjacent surfaces and other items. Comply with indicated maximum dimensions.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver in sections of lengths that can be moved past obstructions in delivery path. Deliver MDBs and components properly packaged and mounted on pallets, or skids to facilitate handling of heavy items. Utilize factory-fabricated type containers or wrappings for MDBs and components to protect equipment from damage. Inspect equipment to ensure that no damage has occurred during shipment.

B. Store indoors in clean dry space with uniform temperature to prevent condensation. Protect from exposure to dirt, fumes, water, corrosive substances, and physical damage.

C. Handle MDBs carefully to prevent physical damage to equipment and components. Remove packaging, including the opening of crates and containers, avoiding the use of excessive hammering and jarring which would damage the electrical equipment contained therein. Do not install damaged equipment; remove from site and replace damaged equipment with new.

1.7 PROJECT CONDITIONS

A. Installation Pathway: Remove and replace access fencing, doors, lift-out panels, and structures to provide pathway for moving main distribution boards into place.

B. Environmental Limitations: Rate equipment for continuous operation under the following, unless otherwise indicated:

1. Ambient Temperature: Not exceeding 55 deg C.
2. Altitude: 1800 m.

1.8 COORDINATION

A. Coordinate layout and installation of main distribution boards and components with other construction and electrical work, including conduit, piping, equipment, adjacent surfaces, raceways, electrical boxes and fittings, and cabling/wiring work. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3 Section "Cast-in-Place Concrete."

1.9 EXTRA MATERIALS

A. Spare Parts: Provide manufacturer's recommended spare parts for emergency replacement and/or one year's maintenance including, but not limited to, the following:

1. One set of fixed and moving contacts for every type of replaceable (consumable) contact set.
2. One operating motor and/or coil for each type of electrically operated circuit breaker.
3. Two sets of each type of indicating lights, fuses, LEDs, control switches, and similar devices subject to failure or breakage at any time.

B. Tools and Instruments: Provide tools and instruments required for normal routine inspection and maintenance and testing of circuit breakers and protective devices as appropriate for type of switchgear supplied.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Approved Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

1. A.B.B
2. Schneider Electric
3. G.E.
4. Siemens

Country of origin is to be submitted for review/approval.

Complete documentation for the factory manufacturing the equipment is to be submitted including but not limited to, local and international experience, quality certificates, quality assurance plan, and organization.

2.2 GENERAL REQUIREMENTS

A. Generally: Main distribution boards are to be dead-front type, metal enclosed, multi-cubicle, floor mounted, free standing, with 1000V rated insulation voltage, and 600 V rated operational voltage, with fixed or draw-out switchgear, manually or manually and electrically operated, as shown on the Drawings, with matching vertical sections to form a continuous integral and rigid structure. Outgoing sections are to be of equal width.

B. Generally: Coordinate with Building Automation and Control System (GSM) supplier (if GSM system is specified) and provide all necessary interfaces, relays, transducers, etc, necessary for the functions specified in the GSM schedules and/or shown on the Drawings.

C. Provide at least the following transducers for the MDB :-

Incoming Circuit breakers

- Power factor transducer
- Current transducer (per phase)
- Voltage transducer (per phase)

Outgoing Circuit breakers

- KW transducer
- KWH transducer
- Current transducer (per phase)
- Voltage transducer (per phase)

D. General Construction: Rigidly framed and bolted, with Electro-galvanized sheet steel enclosures, minimum thickness 1.5 mm, phosphatized, primed with rust inhibiting primer and finished with thermal polymerized polyester epoxy powder coating, gray color (RAL 7703 or ANSI 61) to approval. Switchgear is to be vermin, dust and rodent proof, IP42 protection to IEC 60144 for indoor installations, with adequate lifting means and base-frames and capable of being moved into position and directly bolted to floor without additional sills.

E. Ventilation: Compartments are to be ventilated, by approved methods complying with the Standards.

F. Main Distribution Boards are to have a short circuit withstand current of 36kA for 1 sec.

G. Fastenings between structural members are to be bolted.

H. Extension of structure and busbars is to be possible.

I. Arrangement is to permit incoming and outgoing busbars and cables to enter enclosure as indicated on the Drawings and connect at respective terminals without inconvenience to installation or maintenance.

J. Removing Circuit Breakers: Suitable arrangements and equipment are to be provided for extracting, lifting and unloading switchgear from enclosures as appropriate for type of switchgear.

K. Spare and space positions are defined as follows:

1. Spare position: Fully equipped enclosure with switchgear
2. Space position: Fully equipped enclosure ready to receive switchgear.

L. Bus bars: Site rated for normal current as shown on the Drawings or at least site rated to same rating of main circuit breaker frame size, and braced for a symmetrical rms short-circuit duty as specified. Busbars are to be copper, of sufficient size to limit temperature rise to allowable insulation or equipment temperature ratings, and to maximum 90 deg C. Connections and buswork are to be bolted with copper alloy hardware and are to be accessible for inspection and maintenance unless otherwise recommended by the manufacturer and approved by Engineer. Contact surfaces are to be Electro-silver plated.

M. Connections from busbar to switchgear are to be rated to carry full continuous current rating of switchgear frame and are to be insulated.

N. Full size neutral is to be continuous through all sections. Neutral bus is to be insulated and separate from earth bus and connected to it with removable links, at every bus section. Links are to be of the same cross-section of the earth bus.

O. Earth bus is to extend full length of board, firmly fixed to each section in accordance with the Regulations and Standards, complete with two main earthing lugs (one at each end), and required number of feeder protective earth connectors.

P. Earth bus is to be half size of phase buses

Q. Switchboard Type: Switchboard(s) are to be of the following type(s):

1. Form 3.
2. Incoming: Withdrawable motorized type.
3. Tie: Withdrawable motorized type.
4. Outgoing: Fixed type..

R. Withdrawable metal enclosed circuit breaker section is to consist of compartmented unit(s), stationary part with rear bus bar and cable connection compartments and front draw-out circuit breaker assembly. Partitions between sections are to be bolted steel plate and partitions between compartments are to be tough solid insulating removable bolted barriers. Each unit is to have hinged lockable front door with grip-handle and door mounted instrumentation.

S. Draw out circuit breaker assembly is to have disconnecting contacts, wheels and interlocks to prevent connecting or disconnecting circuit breaker unless in the open position, and to prevent closing circuit breaker while racking into any of the three positions (connect, test, disconnect). Racking mechanism and rail assembly are to be approved worm and lever mechanism. It is to be possible to close the unit door with breaker in any of the three positions and when removed. External position indicator is to be provided. Fixed disconnecting primary contacts are to be accessible and replaceable from front and are to be silver plated copper. Moving primary disconnect contacts are to consist of self-aligning, silver plated, spring pressure, finger-cluster, copper contact fitted on line and load studs of circuit breaker.

T. Fixed main circuit breaker section is to individually accommodate main circuit breaker, main cable entry with terminal fitting assembly and metering compartment. Where placed against a wall, accessibility is to be possible from front and sides or only from front of section.

U. Pull Sections: An additional cable pull section is to be provided, depending on actual configuration shown on the Drawing, and subject to Engineer's approval.

2.3 MOLDED CASE CIRCUIT BREAKERS (MCCBs)

A. MCCBs generally are to be thermal-magnetic type for ratings below 400 A frame size, unless otherwise shown on the Drawings. MCCBs 400 A and larger are to be electronic solid-state trip type. All circuit breakers are to be 3-pole unless otherwise shown on drawings.

B. Construction: Totally enclosed, molded case, constructed from high quality, high temperature resistant, tropicalized, molded insulating materials, for normal operation at 70 deg. C within enclosures, to approved standards, provided with quick-make, quick-break, trip-free switching mechanism manually operated by front toggle type handle and automatically tripped under over-current conditions. Multi-pole breakers are to have common integral trip bar for simultaneous operation of all poles. Contacts are to be non-welding silver alloy with arc quenching metallic devices of approved construction. Cable terminals are to be solder-less anti-turn box lug or clamp type with set screws suitable for copper or aluminum cables.

C. Thermal magnetic circuit breakers are to include, on each pole, a bi-metallic inverse time-delay over current trip element for small overloads and instant magnetic over current trip elements for operation under short-circuit conditions. Circuit breakers 250 A frame size and larger are to have adjustable instantaneous trips.

D. Thermal over-current trips are to be compensated to allow for ambient temperature higher at breaker than at protected circuit or device. Compensation is to be applicable between 25 and 50 deg. C. In case of adjustable thermal settings, range of adjustment is not to exceed maximum trip rating shown on the Drawings.

E. Electronic trip circuit breakers are to have solid state trip units with long time delay setting range at least between 0.5 and 1.0 times maximum trip rating, short time delay range 3 to 10 times maximum trip rating with maximum clearing time of 0.2 seconds, and instantaneous protection adjustable from 5 to 10 times continuous rating. Solid state trip units are to be insensitive to changes in ambient temperature between -20 and +55 deg. C. Earth fault protection is to be built into trip unit where specified, and is to be adjustable between 0.2 and 0.6 normal phase current pick-up with maximum time delay of 0.2 seconds, and is to be suitable for connection to external current sensor. Push-to-trip button is to be provided on cover for testing the trip unit.

F. Tripped Position: When tripped automatically by over current condition, operating mechanism of circuit breaker is to assume an intermediate position clearly indicated by the handle between on and off positions.

G. Interchangeable Trips: Circuit breakers greater than 400 A frame size are to have interchangeable thermal and electronic trip units.

H. Sealing: Non-interchangeable trip circuit breakers are to have sealed covers. Circuit breakers with interchangeable trips are to have trip unit covers sealed to prevent tampering.

I. Circuit breaker ratings are to be non-current limiting, fully rated (100%) with continuous duty at site conditions, and with frame size and interrupting capacity to IEC 60947-2, sequence II (rated service short-circuit breaking capacity), and maximum trip rating as shown on the Drawings. Interrupting capacities at

specified voltage and frequency are to meet IEC 60947-2 test sequence I, II, III and IV for circuit breakers of utilization category B (with intended short time withstand capability).

J. Accessories: Circuit breaker design is to allow addition of electrical operator, control and interlocking functions, under-voltage release, shunt-trip coils, alarm and auxiliary switches, padlocking devices, key-lock devices, and the like.

2.4 METERING INSTRUMENTS

A. Generally: Instruments are to be housed in enameled, square, metal cases for flush installation. Scales and markings are to be protected and sealed. Accuracy of instruments is to be within 2% unless otherwise specified.

B. Voltmeters: Moving iron type, with center zero adjuster, range 1.25 times nominal system voltage, 90 degree angle, size 76 x 76 mm.

C. Voltmeter Selector Switch: 7-position rotary type.

D. Ammeters: Moving iron type, with center zero adjuster, range 2 times nominal circuit amperage, 90 degree angle, size 76 x 76 mm.

E. Provide ammeters and pilot lights for each phase.

F. Provide p.f. meter moving iron type with center zero adjuster, size 76 x76mm.

G. Current Transformer (CT): Indoor dry type, rated secondary current 5 A. Rated primary current, core size and accuracy are to be determined in accordance with nominal current of plant protected, short-circuit level and burden.

H. Voltage Transformer (VT): Provide where required, complete with primary and secondary fuses and disconnecting device.

2.5 WIRING

A. Arrangement: Wiring is to be modularly and neatly arranged on master terminal boards with suitable numbering strips and appropriate cartridge type fuses where required.

B. Connections are to be made at front of terminal board and with no live metal exposed.

C. Metal cases of instruments, control switches, relays etc. are to be connected, by bare copper conductor's not less than 2.5 mm2 section, to nearest earthing bar.

D. Control Wiring: Copper, PVC insulated, 85 deg. C, 600 V grade, and PVC sheathed for multi-core cables. Finely stranded copper conductor, silicon rubber insulated cables are to be used in proximity to higher temperature components and as flexible cable.

E. Ferrules: Wires are to be fitted with numbered ferrules of approved type at each termination.

2.6 MISCELLANEOUS

A. Anti-condensation heaters with disconnect switch and pilot lamp are to be provided in switchboard, controlled by thermostat and/or hygrostat.

B. Schematic and wiring diagram is to be provided suitably located within each cubicle.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine elements and surfaces to receive main distribution boards for compliance with installation tolerances and other conditions affecting performance. Notify Engineer in writing of conditions detrimental to proper completion of the work.

1. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install main distribution boards as indicated, in accordance with manufacturer's written instructions, and with recognized industry practices; complying with applicable requirements of applicable standards or codes approved.

B. Equipment Bases: Ensure that concrete bases and foundations provided for installation of equipment are constructed in accordance with approved shop and construction drawings and equipment manufacturers' drawings and that holes for fixing bolts and provisions for passage of cables etc. are provided as required.

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from main distribution board units and components.

D. Cable Trenches: Ensure that trench construction and covers provided for installation of power and control cables are in accordance with approved shop and construction drawings.

E. Built-in Items: Ensure that equipment supports, fixings and the like, and sleeves for passage of feeders and cables which are to be built into concrete foundations, bases, cable trenches or building structure are provided as and when required and that they are properly installed.

F. Equipment: Install on concrete bases etc., and assemble completely plumb and level, before grouting in holding-down bolts.

G. Supports and Terminations: Install all incoming and outgoing cable supports, cable ends and termination fittings required for power and control cables.

H. Relays: Set in accordance with manufacturer's instructions and in accordance with an approved scheme.

I. Make Good damage painted surfaces, clean and apply rust-inhibiting prime coat and two finishing coats of approved enamel upon delivery of equipment to site, or as required by Engineer.

J. Operating Instructions: Frame and mount the printed basic operating instructions for main distribution boards, including control and key interlocking sequences and emergency procedures. Fabricate frame of finished wood or metal and cover instructions with clear acrylic plastic. Mount on front of main distribution boards.

3.3 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Division 16 Section "Basic Electrical Materials and Methods."

B. Main Distribution Board Nameplates: Label each main distribution board compartment with engraved metal or laminated-plastic nameplate mounted with corrosion-resistant screws.

3.4 CONNECTIONS

A. Install equipment-grounding connections for main distribution boards with ground continuity to main electrical ground bus.

B. Tighten electrical connectors and terminals, including screws and bolts, according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in applicable Standards.

3.5 FIELD QUALITY CONTROL

A. Equipment: Inspect equipment upon delivery to Site and report any damage to Engineer.

B. Switchgear: Inspect and check switchgear for completeness, component ratings, types, sizes, and wiring connections. Check phasing of busbars, contacts and clearances.

C. Prior to energization of circuitry, check all accessible connections to manufacturer's torque tightening specification.

D. Tests: After installation and before hand-over, carry out all visual and mechanical inspection and electrical tests required by the governing codes and any other tests the Engineer may require to check compliance of installation with the Specification, including, but not limited to, the following. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

1. Insulation resistance tests for each main distribution board bus, component, connecting supply, feeder, and control circuit.

2. Continuity tests of each circuit.
3. Operational tests.

E. Main and Control Circuits: Using 1000 V megger (2000 Megaohm range), check insulation resistance between phases, between phases and earth/enclosure and between neutral and earth.

F. Primary Injection Tests: Provide portable test equipment to test time-delay characteristics of circuit breakers by simulating an overload or fault condition. Measure and record all test results and ambient conditions and compare with manufacturer's data.

G. Instantaneous Trip Elements: Test by high current primary injection, using high-current primary injection test-sets and reports all readings.

H. Routine Tests on Site: Carry out on every main distribution board in accordance with the Standard specified (IEC 60439 or BS 5486: Part 1) for FBAs assembled from standardized components outside the works of the manufacturer. Routine tests are also to be carried out on every FBA, delivered to site, if requested by Engineer.

3.6 ADJUSTING

A. Set field-adjustable switches and circuit breaker trip ranges.

3.7 CLEANING

A. On completion of installation, inspect interior and exterior of main distribution boards. Remove paint splatters and other spots. Vacuum dirt and debris; do not use compressed air to assist in cleaning. Repair exposed surfaces to match original finish.

END OF SECTION 1007

SECTION 1008 - PANELBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Conditions of Contract, apply to this Section.

1.2 SUMMARY

A. Panelboards for distribution and sub distribution of electric power and for protection of circuits, including fixing and supporting materials and materials for termination of feeders, sub-circuits and branch circuits for the following types:

1. Lighting and appliance branch-circuit panelboards.
2. Distribution panelboards.

B. Connection to GSM system, including interface elements such as relays, transducers, etc. and /or shown on the Drawings.

C. Related Sections include the following:

1. Division 100 Section "Basic Electrical Materials and Methods".

1.3 DEFINITIONS

A. MCB: Miniature circuit breaker.

B. MCCB: Molded case circuit breaker.

C. LP, PP, SDP: lighting panelboards, power panelboards and subdistribution panelboards respectively, for secondary lighting and power distribution with either miniature circuit breaker (MCB) or molded case circuit breaker (MCCB) protection on sub-feeder or branch circuits, as shown on the Drawings.

D. DP: Distribution panelboards for power distribution with MCCB protection on main incoming and outgoing feeder circuit breakers Type 1 or Type 2.

E. Distribution panelboards or final branch circuit panelboards supplied from emergency source are prefixed with the letter E.

F. ELCB: Earth leakage circuit breaker.

G. RMS: Root mean square.

1.4 SUBMITTALS

A. Equipment Data: Submit data for approval including, but not limited to, the following:

1. Manufacturers' catalogues indicating specific equipment selected
2. Types of panelboards and circuit breaker characteristics including duties and ratings compensation at and above 40 deg C ambient conditions and corresponding temperatures within the enclosures.
3. Dimensions of panels and specific contents of each panelboard.
4. Integrated equipment tabulations for coordinated short- circuit series combinations of circuit breakers.

B. Tests and Certificates: Submit complete certified manufacturer's type test and routine test records in accordance with the Standards.

C. Shop and Construction Drawings: Submit drawings for approval including, but not limited to, the following:

1. Exact composition of each panelboard, indicating busbar rating, frame and trip ratings of circuit breakers.
2. Typical installation details of panelboards, indicating main feeder and branch circuit conduit connections, terminal provisions, tags, labels, mounting methods and materials used.

D. Details of Electrical Closets: Submit details to verify clearances, spaces and ventilation of the installation of proposed equipment, prior to starting construction.

E. Field Test Reports: Submit written test reports and include the following:

1. Test procedures used.
2. Test results that comply with requirements.
3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

F. Panelboard Schedules: For installation in panelboards submit final versions after load balancing.

G. Maintenance Data: For panelboards and components to include in maintenance manuals specified in Division 1. In addition to requirements specified in Division 1 include the following:

1. Manufacturer's written instructions for testing and adjusting over-current protective devices.

2. Time-current curves, including selectable ranges for each type of over-current protective device.

1.5 QUALITY ASSURANCE

A. Comply with

1. IEC 60439-1 "Low Voltage Switchgear and Control Gear Assemblies".
2. IEC 60947-2 "Molded case circuit breakers"
3. IEC 60898 "Miniature circuit breakers"
4. Other components where not specified are to comply with the relevant IEC standards

1.6 COORDINATION

A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, and encumbrances to workspace clearance requirements.

1.7 SCHEDULES

A. Schedules shown on drawings indicate the designation and required type of panelboard using the following criteria:

1. Type of construction (MCB or MCCB), referring to type of branch circuit breakers.
2. Voltage, number of phases and wires.
3. Branch circuit breaker trip rating and wire size.
4. Main circuit breaker trip rating and frame size (maximum continuous rating) for MCCB and MCB.
5. Short-circuit interrupting capacity (IC) in kA.
6. Special arrangement or provisions.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Approved Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

1. A.B.B
2. Schneider Electric
3. G.E.
4. Siemens.

Country of origin is to be submitted for review/approval.

Complete documentation for the factory manufacturing the equipment is to be submitted including but not limited to, local and international experience, quality certificates, quality assurance plan, and organization.

2.2 GENERAL REQUIREMENTS

A. Rated insulation voltage is to be in accordance with the respective standards.

B. Panelboards are to be totally enclosed, dead front type, protection code IP 42 for indoor installations and IP 54 for outdoor installations, in accordance with IEC 60144, and are to be factory designed and assembled.

C. Earthing bar is to be half size the phase busbars.

D. Neutral bar is to be sized as the phase bus bars.

E. Protection is to be fully rated throughout the systems.

F. Circuit breakers are to be non-fused type.

G. Circuit Breaker Arrangement: Panelboards are to have one main incoming circuit breaker and the required number of branch circuit breakers, arranged as shown on the schedules, including spare circuit breakers and spaces for future expansion. Three-phase panelboards are to be designed for sequence phase connection of branch circuit devices.

H. Branch Circuit Numbering: On 3-phase panelboard schedules, circuits 1 and 2 are to be connected to red (R) phase, 3 and 4 to yellow (Y) phase, 5 and 6 to blue (B) phase etc., to conform to branch circuit numbering shown on the drawings.

2.3 PANELBOARD ENCLOSURES

A. Type: General purpose type, suitable for relevant ambient conditions, flush or surface mounted as shown on the drawings, comprising box, trim, or trim and door to approved manufacturer's standards and sizes.

B. Construction: Box, trim and doors where required, are to be Electro-galvanized sheet steel of gauges not less than specified and in accordance with the standards. Welded joints are to be galvanized after manufacture. Gutter spaces are to conform to the standards, adequate for the utilized cables/wires subject to the engineers' approval and in no case less than 100 mm on all sides. Enclosure is to have pre-designed angles or threaded end studs to support and adjust mounting of interior panelboard assembly.

C. Trims are to cover and overlap front shield, covering all terminals and bus compartments, to form a dead front panel. Trims are to be fixed to cabinet/box by quarter-turn clamps engaging flange of box (use of screws engaging holes in flange of box is not acceptable). Screws where used are to be oval-head, countersunk and flush. Trims for flush mounted panelboards are to overlap box and front shields by at least 20 mm. Trims for surface mounted panelboards are to be exactly sized to form flush fit to box.

D. Doors are to have concealed hinges integral with trim, and flush combination cylinder lock and catch. Doors over 1000 mm high are to have vault-type handle and multiple point latch mechanism. Locks are to be keyed alike.

E. Finish: Inner and outer surfaces of cabinet/boxes, trims, doors etc. Are to be cleaned, phosphatized, chrome passivated and treated with final thermosetting epoxy powder modified by polyester resins providing high resistance to mechanical injury, heat, acid and alkali solvents, grease, aging and corrosion and of standard gray color to the approval of Engineer.

F. Directories under glassine, or an approved alternative durable arrangement, are to be provided on inside face of doors, or in metal label holders when trim without doors are specified. Directories are to be typed to identify panelboards and clearly indicate circuit number and description of load.

G. Outdoor enclosures are to be heavy duty sheet steel cabinets, minimum 1.5 mm thick, fully weatherproofed (IP 54), without knockouts, but with removable sealed/gasketed bottom gland plates and gasketed doors.

2.4 BUSBARS

A. Type: One piece, 98% pure electrolytic copper, based on total maximum operating temperature of 90 deg C at any point of the bus, at full continuous rating. Bolted or clamped contact surfaces are to have maximum current density not exceeding requirements of the approved standards. Aluminum is not to be used for busbars or panelboard parts.

B. Design: Busbars are to be shrouded/insulated and rigidly designed so that branch circuit devices can be removed without disturbing adjacent units or changed without additional machining, drilling or tapping. Busing is to be full size without reduction. Busing and blank plates are to allow installation of future circuit devices, where indicated on the drawings.

C. Rating: Busbar rating is to be at least equal to main-circuit breaker frame size. Where no main circuit breaker is required, busbars are to have main lugs or disconnect switch, with nominal rating equal to standard circuit breaker frame sizes, and as shown on the drawings.

D. Short-circuit Duty: Busbars are to carry at least 125% of the maximum short-circuit level at point of application for one second, without showing any signs of degradation.

E. Terminals and connections are to be anti-turn, solder-less screw-pressure type. Screws and bolts used for making copper/copper connections are to be hard copper alloy with lock washers (riveted bus connections are not acceptable).

F. Neutral bar is to be solid and fully insulated from cabinet or box. One solder-less box type set-screw connector is to be provided for neutral wire of each branch circuit and one bolted clamp-type connector or anti-turn lug with set-screw for main incoming neutral wire. Neutral is to be fully sized and rated as for phase busbars.

G. Earthing bar is to be copper, brazed to panelboard cabinet, with bolted pressure connector for main conductor and one set-screw-type tunnel terminal for each outgoing conductor, to provide secure and reliable contact with all metal parts and enclosure.

2.5 MOLDED CASE CIRCUIT BREAKERS (MCCBs)

A. Type: Tested to approved standards, totally enclosed, molded case, constructed from high quality, high temperature resistant, tropicalized, molded insulating materials, for normal operation at maximum temperature within enclosures at point of application, and provided with front operated single toggle type handle mechanism for manual operation of main contacts in addition to automatic operation under over-current conditions. Multi-pole breakers are to have common integral trip bar for simultaneous operation of all poles. Ampere rating is to be clearly visible. All terminals are to be box lug or clamp type with set screws, suitable for copper or aluminum conductors.

B. Circuit Breaker Trip Units: Unless otherwise specified or shown on the drawings, circuit breakers up to and including 400 A frame size, are to be thermal-magnetic type, having bi-metallic inverse time delay over-current element for small overloads and instantaneous magnetic over-current trip element for operation under short-circuit conditions on each pole. Circuit breakers 250 and larger are to have adjustable instantaneous trips.

C. Switching Mechanism: Quick-make, quick-break type, with positive trip-free operation so that contacts cannot be held closed against excess currents under manual or automatic operation. Contacts are to be non-welding silver alloy with approved arc-quenching devices of metallic grid construction.

D. Trip current rating (amps) indicates nominal maximum rating at which overload element is set to operate.

E. MCCBs for LPs, PPs, SDPs and DPs Type 2: Comply with IEC60947-2 test sequences I, II, utilization category A, and are to have rated ultimate short circuit breaking capacities (sequence III) to meet the electrical requirements at the panelboard location, with preferred ratings in accordance with following tables.

F. MCCBs for DP Type 1: Rated for maximum voltage of 600v A.C., 250 v D.C. and utilization category b (with an intended short time withstand capability), and are to have rated service short circuit breaking capacities (sequence ii) with suitably selected frame sizes and trip ranges to meet the electrical requirements at the distribution panelboard location and schedules shown on the drawings, with declared ratings as percentage (100%, 75% or 50%) of the ultimate ratings as quoted by the circuit breaker manufacturer marked on the circuit breaker rating plate.

G. Frame size is defined as maximum continuous current rating of circuit breaker which corresponds with its maximum trip range listed below and which is to be related to minimum acceptable short-circuit interrupting ratings, based on fully rated interrupting duties: normal duty (N), high break (H), or current limiting (L), as specified.

H. Frame sizes are generally to be selected with minimum interrupting capacities at specified voltages and rated frequency, in accordance with the following table:

Trip range frame size(amperes)	Minimum Symm. rms rated breaking capacity (ultimate in kA)			Rating volts(A. C)
	N	H	L	

Thermal-magnetic				
15-100 (1,2,3P)	**14**	**-**	**-**	**277/480**
15-150 (1,2,3,4p)	**25**	**65**	**100**	**277/480**
70-250 (2,3,4p)	**25**	**65**	**100**	**480**
100-400(2,3,4p)	**35**	**65**	**100**	**480**
Electronic				
400-800 (2,3p)	**35**	**65**	**100**	**480**
800-1200 (2,3p)	**50**	**65**	**100**	**480**

Trip range frame size(amperes)	**Minimum Symm. rms rated breaking capacity (ultimate in kA)**			**Rating volts(A. C)**
	N	**H**	**L**	
Thermal-magnetic				
15-100 (1p)	**18**	**-**	**-**	**220/240**
15-100 (2,3p)	**18**	**-**	**-**	**380/415**
15-160 (2,3,4p)	**35**	**60**	**100**	**380/415**
70-250 (2,3,4p)	**35**	**60**	**100**	**380/415**
160-400 (2,3,4p)	**35**	**60**	**100**	**380/415**
Electronic				
400-800 (2,3p)	**40**	**60**	**100**	**380/415**
800-1250 (2,3p)	**50**	**65**	**100**	**380/415**

Trip range frame size(amperes)	**Minimum Symm. rms rated breaking capacity (ultimate in kA)**			**Rating volts(A. C)**
	N	**H**	**L**	
Thermal-magnetic				
15-100 (1p,2p,3p)	**10**	**-**	**-**	**120/240**
15-100 (1p)	**18**	**65**	**-**	**240**
15-160 (1p)	**25**	**65**	**-**	**240**
15-160 (2,3,4p)	**65**	**100**	**150**	**240**
70-250 (2,3,4p)	**65**	**100**	**150**	**240**
100-400(3,4p)	**65**	**100**	**150**	**240**
Electronic				
400-800 (2,3,4p)	**65**	**100**	**150**	**240**
600-1250 (2,3,4p)	**65**	**100**	**150**	**240**

I. Tripped Position: When tripped automatically by over-current condition, operating mechanism of circuit breaker is to assume an intermediate position clearly indicated by the handle between on and off positions.

J. Interchangeable Trips: Thermal-magnetic trip circuit breakers of frame size 400 A frame size and larger are to have interchangeable trip units.

K. Sealing: Circuit breakers with non-interchangeable trip units are to be sealed. Circuit breakers with interchangeable trip units are to have trip unit covers sealed to prevent tampering.

L. Compensation: Thermal over-current trips are to be ambient temperature compensated between 25 and 50 deg C.

M. Electronic trips units, applicable to circuit breakers 400 A frame size and larger, are to be solid state with long time delay settings between 0.5 and 1.0 times maximum trip rating, short time delay range of 3 to 10 times maximum trip rating with a maximum clearing time of 0.2 seconds, and instantaneous protection adjustable from 5 to 10 times continuous rating. Solid state trip units are to be insensitive to changes in ambient temperature between -20 and +55 deg C. Earth fault protection is to be built into trip unit where specified, and is to be suitable for connection to external current sensor. Push-to-trip button is to be provided on cover for testing the trip unit.

N. Accessories: Circuit breakers are to be designed to accommodate standard attachments including shunt-trip, under-voltage release, combined auxiliary and alarm switches, and electrical operator to any circuit breaker of rating (frame size) 100 A and over. Padlocking devices are to be provided, where shown on the Drawings.

O. Residual current operated earth leakage trip devices (RCDs) are provided as add-on or built-in earth leakage accessories, where required and as shown on the Drawings. Protection against earth fault current, in addition to over-current and short-circuit protection, is to be in accordance with the Regulations. Trip current sensitivity on breakers for branch circuits is to be 30 mA, and for main breakers ratings are to be as shown on the Drawings. Circuit breakers are to include current transformer with tripping coil assembly, test button and trip free mechanism to ensure circuit breaker cannot be held closed against earth faults.

P. Current Limiting Circuit Breakers: Molded case type without fusible elements. When operating within current limiting range, the I2t of let-through current is to be less than 1/2 cycle wave of symmetrical protective short-circuit current as compatible with breaker construction.

Q. Current limiting circuit breakers are to have, on each pole, adjustable inverse time-delay over-current characteristics for overload protection and instantaneous trip for short-circuit protection. Operation of main contacts is to be based on Electro-magnetic repulsion forces between contacts created by fault current. Ratings are specified at rated voltage for an rms value of prospective short-circuit current.

2.6 EQUIPMENT FOR ELECTRICITY METERING BY EMPLOYER

A. Compact, modular, din rail mounted KWH meter with digital display (similar to Schneider electric ME multi9 series or ABB EIB delta range or approved equal).

B. Meter: Electronic kilowatt-hour/demand measuring to record electricity used is to be according to the following specification

1. Kilowatt-Hour Display: Digital liquid crystal.
2. Accuracy class 2
3. Comply with IEC 1036/1268
4. Resistant to shock and vibration and can be mounted in any position.
5. DIN rail mounted

6. Single phase or three phase as shown on drawings.
7. Rating up to 63A without current transformers, for rating greater than 63 A provide suitable current transformer.

C. Current-Transformer Cabinets: Recommended by metering equipment manufacturer for use with sensors indicated.

2.7 MINIATURE CIRCUIT BREAKERS (MCBs)

A. Type: Thermal magnetic non-adjustable type, tested in accordance with IEC 60898 .

B. Minimum short-circuit breaking capacities (to IEC 60947-2) are to be as follows:

1. 6 - 100 A MCB: 6, 10 or 16 kA at 240/415 v A.C.

C. Construction: MCBs are to be tropicalized for operation at ambient temperatures up to 70 degree C within panelboard enclosure and humidity up to 95%, and are to be constructed from high quality, high temperature, molded insulating materials. Guaranteed duties and characteristics are to be submitted for temperatures above 40 deg C.

D. MCBs and combination devices are to be modular, of unified profile and suitable for mounting either to a standard din rail, or a plug-in system.

E. Operation: Under overload conditions, thermal tripping is to provide close protection of insulated conductors. Under short-circuit conditions, magnetic trip is to operate at 7 - 10 times normal rated current (type 3 characteristic). Magnetic operation is to be in the current limiting region and opening time is not to exceed 5 milliseconds.

F. Ratings: Preferred rated currents are to be 6, 10, 15, 20, 25, 30, 40, 50, 60, 80 and 100 A, calibrated at 40deg.C, available as 1, 2, 3 and 4-pole circuit breakers. De-rating above 40 deg C is not to exceed 1% per deg C and loading is not to exceed 70% of circuit breaker rating.

G. Residual current devices for earth leakage protective circuit breakers are to be add-on devices, or built-in and integral with the standard circuit breaker. Non-adjustable sensitivities of 30 mA, 100 mA and 300 mA are to be available for all ratings of 2-pole and 4-pole circuit breakers.

H. Auxiliaries where shown on the drawings, are to include alarm switch, auxiliary switch, shunt trip, under voltage trip and similar units which are to be modular additions to the circuit breakers.

2.8 MOLDED CASE SWITCH (MCS)

A. Molded Case Switch: Non-automatic on/off switching device of equal construction to equivalent circuit breaker, having no over-current or fault protective elements, but marked with maximum current withstand and voltage rating.

2.9 DISTRIBUTION PANELBOARDS (DP)

A. DP Type 1: Form 1 to IEC60439-1, and have a rated insulation voltage of 1000V and a rated operational voltage of 600V A.C., 240 V D.C., surface mounted to wall or free standing , with doors (unless otherwise shown on the Drawings), suitable for ratings of main breaker and busbars ranging from 225 A to 1200 A, 3-phase, 4-wire (or 3-wire where specifically indicated), suitably and orderly arranged for any selected combination of branch MCCBs ranging from 150 A to 1200 A frame size and short-circuit interrupting ratings as shown on the Drawings. Circuit breakers smaller than 225 A frame size, where indicated, may be grouped on an integral sub-assembly mounted to main chassis.

B. DP Type 2: Form 1 to IEC60439-1, and have a rated insulation voltage of 750V and a rated operational voltage of 440V A.C., 240 V D.C. Panelboard is to be recessed or surface mounted type, as shown on the Drawings, complete with trim and door, adjustable trim fixation for flush panels, and with ratings of main circuit breaker and busbars of 100 A, 225/250 A, 400 A or 600 A, 3-phase, 4-wire, with 2 or 3-pole branch circuit breakers, 100 A or 150/160 A frame size for voltages up to 600 V A.C., and 100 A to 225 A frame size at 240 V A.C.

C. Construction: Sheet steel, minimum 1.5 mm thick for cabinet/box and minimum 2 mm thick for trim or trim and door. Fronts are to be single or twin covers to shield circuit breakers, terminals and live ends.

D. Interior of panelboard is to be pan assembly consisting of galvanized sheet steel chassis minimum 2 mm thick, folded, flanged and reinforced, with busbars vertically arranged and mounted on molded insulators.

E. Molded insulators are to have minimum temperature rating of 130 deg C and insulation grade of 3.5 kV for one minute.

F. Circuit breakers are to be mounted in twin arrangement (except for larger circuit breakers) and bolted rigidly to copper cross and center bus connectors.

2.10 FINAL BRANCH CIRCUIT, POWER AND SUB-DISTRIBUTION PANELBOARDS - GENERALLY

A. Arrangement: Comprise set of homogeneous branch circuit breakers with unified profile and base, and one main circuit breaker. Single and multi-pole circuit breakers or other devices are to occupy modular spaces. Accommodation of contactors and split-bus arrangement or other devices is not to change regularity of standard box width.

B. Indoor Enclosure: Sheet steel, minimum 1.0 mm thick for box/cabinet and minimum 1.5 mm thick for front shield, trim and door. Fixings for flush trim are to be adjustable to allow for mis-alignment between box and wall surface. Wiring spaces (gutters) are to be at least 100 mm wide. Larger gutters are to be provided where tap-off insulated split connectors are required. Knockouts are to be provided in top or bottom of enclosures and are to provide a neat and uniform conduit/cable terminal arrangement.

2.11 FINAL BRANCH CIRCUIT, POWER AND SUBDISTRIBUTION PANELBOARDS - TYPE MCCB

A. Type: Rated insulation voltage rating 750V and a rated operational voltage of 600V A.C. .250 V D.C. single-phase and neutral (SPN) or 3-phase and neutral (TPN), with bolted 1, 2, or 3-pole MCCBs on branch circuits and 2, 3 or 4-pole MCCB on main incoming, listed by UL File No. E2269 or equal, and meeting USA Specification W-P-115b Type 1 Class 1.

B. Branch circuit breakers are to be 1, 2 or 3-pole, rated 100 A frame size, with trip ratings between 15 A and 100 A, and compatible ICs, selected from normal (N), high-break (H) or current-limiting (L) range.

C. Main circuit breaker is to be 2 or 3-pole 100 A, or 2, 3 or 4-pole 160 A, 225/250 A or 400 A continuous rating (frame size), with trip ratings and fully rated non-current limiting ICs of normal (N) or high-break (H) ranges, with or without residual current device (RCD) as indicated on the Drawings.

D. Assembly: Busbars are to be rigidly fixed on molded insulators to back pan in vertical arrangement. Branch circuit breakers are to be bolted in twin arrangement to rigid copper cross and center bus connectors. Back pan assembly is to be removable and fixed to four threaded studs integral with cabinet.

2.12 FINAL BRANCH PANELBOARDS - TYPE MCB

A. Type: Rated insulation voltage rating of 600V and a rated operational voltage of 600V.

B. Internal Assembly: Comprise removable back plate or back pan of rigid construction, attached to enclosure by four captive screws through keyhole fixings, and provided with DIN rails in horizontal arrangement for SPN panels and in vertical arrangement for TPN panels. Assembly is to be complete with neutral terminal block, earthing bar and one piece insulated bolt-on/comb-type phase busbar. Busbars are to be single-phase or 3-phase with spade connectors for fixing by tightening a single screw on circuit breaker. Insulation is to be high thermal rating, capable of carrying maximum short-circuit current for one second without overheating beyond acceptable limits required by the Standards. Panelboards are to comply with BS 5486 Part 12.

C. Internal Assembly: Comprise removable back plate or back pan of rigid construction, attached to enclosure by four captive screws through keyhole fixings, and provided with busbars in horizontal arrangement for SPN panels and in vertical arrangement for TPN panels. Assembly is to be complete with neutral terminal block, earthing bar and one-piece insulated phase busbar. Busbars are to be single-phase or 3-phase with spade connectors for fixing by tightening a single screw on circuit breaker. Insulation is to be high thermal rating, capable of carrying maximum short-circuit current for one second without overheating beyond acceptable limits required by the Standards.

D. SPN type panelboards are to be suitable for 240 V maximum service voltage, single-phase and neutral, with MCBs on branch circuits and main incoming.

E. SPN type main circuit breaker is to be double-pole MCB, with or without earth leakage device (RCD), as shown on the Schedules.

F. Single-pole and double-pole MCBs for 240 V service, are to have trip ratings between 6 A and 50 A, with ICs as required in the Schedules.

G. TPN type panelboards are to be suitable for up to 415 V A.C. maximum service voltage, 3-phase and neutral, with MCBs on branch circuits and 3 or 4-pole MCB or MCCB main incoming, as shown in the Schedules or on the Drawings.

H. Triple-pole branch circuit breakers are to have trip ratings between 6 A and 100 A, with IC as required in the Schedules.

I. TPN type panelboard main circuit breakers are to be MCB or MCCB, 100A continuous current rating, with trip range from 25 A to 100 A, or 225 A MCCB with trip range 70 A to 225 A, normal (N) or high-break (H) duty with/without RCD as shown on the Drawings.

J. Short-circuit Rating: TPN panelboards may only have integrated equipment (series) short-circuit ratings in accordance with clause paragraph F of Article 2.2 "GENERAL REQUIREMENTS" hereof.

2.13 FINAL BRANCH CIRCUIT PANELBOARDS; SPLIT-BUS MCCB/MCB TYPES

A. Assembly is to be as specified for MCB or MCCB type of branch circuit panelboard, but with split-bus arrangement, part of which is controlled by in-built submain contactor or circuit-protective device for group control of a number of branch circuits. Panelboard is to have main circuit breaker for protection and isolation.

B. Contactors: 2 or 3-pole, Electro-magnetic type, class AC 5a or AC 5b to 60947-4, designed to withstand large initial currents of discharge lamps or tungsten lamp loads respectively, and rated not less than overload setting of protective device upstream. Contacts are to be double break, silver cadmium plated, having self-cleaning wiping action. Control is to be provided by phase-neutral (maximum 220 V) split-coil, for on/off activation by local and/or by remote direct-wired, on/off push buttons. Contactor is to be mechanically latched. Control circuit is to be fused. Auxiliaries are to include local pilot light, parallel remote indicating circuit, 2 N.O. and 2 N.C. auxiliary contacts.

2.14 REATIL POWER ENTRY BOX

A. General: 400 x 700 mm x 200 mm (W x H x D) Steel box containing MCCB circuit breaker, rate as per box type and a space for the utility KWH meter.

B. Construction: Box, trim and doors where required, are to be Electro-galvanized sheet steel of gauges not less than specified and in accordance with the standards. Welded joints are to be galvanized after manufacture. Gutter spaces are to conform to the standards, adequate for the utilized cables/wires subject to the engineers' approval and in no case less than 100 mm on all sides. Enclosure is to have pre-designed angles or threaded end studs to support and adjust mounting of interior panelboard assembly.

C. Doors are to have concealed hinges integral with trim, and flush combination cylinder lock and catch.

D. Finish: Inner and outer surfaces of cabinet/boxes, trims, doors etc. Are to be cleaned, phosphatized, chrome passivated and treated with final thermosetting epoxy powder modified by polyester resins providing high resistance to mechanical injury, heat, acid and alkali solvents, grease, aging and corrosion and of standard gray color to the approval of Engineer.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Fixing Generally:

1. Align, level and securely fasten panelboards to structure
2. Fix surface mounted outdoor panelboards at least 25mm from wall ensuring supporting members do not prevent flow of air
3. Do not use connecting conduits to support panelboards
4. Close unused openings in panelboard cabinets.

B. Panelboard Interiors: Do not install in cabinets until all conduit connections to cabinet have been completed.

C. Wiring Inside Panelboards: Neatly arranged, accessible and strapped to prevent tension on circuit breaker terminals. Tap-off connections are to be split and bolted type, fully insulated.

D. Trim: Fix plumb and square prior to painting. Fix trim for flush mounted cabinets flush with wall surface finish.

E. Protection: Treat concealed surfaces of recessed cabinets with heavy field application of waterproof compound prior to installation.

F. Mounting Heights: Top of trim 1880 mm above finished floor, unless otherwise indicated.

G. Mounting: Plumb and rigid without distortion of box. Mount recessed panelboards with fronts uniformly flush with wall finish.

H. Circuit Directory: Create a directory to indicate installed circuit loads after balancing panelboard loads. Obtain approval before installing. Use a computer or typewriter to create directory; handwritten directories are not acceptable.

I. Install filler plates in unused spaces.

J. Provision for Future Circuits at Flush Panelboards: Stub four empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future. Stub four empty conduits into raised floor space or below slab not on grade.

3.2 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Division 16 Section "Basic Electrical Materials and Methods".

B. Panelboard Nameplates: Label each panelboard with engraved metal or laminated-plastic nameplate mounted with corrosion-resistant screws.

3.3 CONNECTIONS

A. Install equipment-grounding connections for panelboards with ground continuity to main electrical ground bus.

B. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values.

3.4 FIELD QUALITY CONTROL

A. Generally: Carry out all tests, required by the governing codes and by the Engineer, on panelboards after installation, to verify compliance with the specifications and standards. Inspect conditions within panelboards and verify insulation conditions by use of a megger.

B. Circuit Breakers: Tests are to include operation of every circuit breaker manually. Check automatic operation of selected circuit breakers, as required by Engineer, by applying necessary short-circuit, overload and earth leakage current for tripping circuit breaker as applicable and compare with manufacturer's data/characteristic curves. Measure and report ambient temperature inside enclosure.

C. Insulation Check Tests: Carry out insulation tests on all busbars, between phases and between phases and earth/cabinet, and between neutral and earth. Record all readings, using 500 V megger for equipment on 240 V systems, and 1000 V megger for equipment on systems up to 600 V, for 1-minute, with circuit breakers in open position.

D. Routine tests on site are to be carried out, in accordance with the Standards, on all panelboards assembled from standardized components of the manufacturer outside the works of the manufacturer.

E. Prepare for acceptance tests as follows:

1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

F. Testing: After installing panelboards and after electrical circuitry has been energized, demonstrate product capability and compliance with requirements.

3.5 ADJUSTING

A. Set field-adjustable switches and circuit breaker trip ranges.

3.6 CLEANING

A. On completion of installation, inspect interior and exterior of panelboards. Remove paint splatters and other spots. Vacuum dirt and debris; do not use compressed air to assist in cleaning. Repair exposed surfaces to match original finish.

END OF SECTION 1008

SECTION 1009 - MOTOR CONTROL CENTERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Conditions of Contract, apply to this Section.

1.2 SUMMARY

A. This Section includes motor control centers and panels for use on ac circuits rated 600 V and less.

B. Related Sections include the following:

1. Division 100 Section "Basic Electrical Materials and Methods".
2. Division 100 Section "Switchboards" for circuit breakers.
3. Division 100 Section "Raceways and Boxes" for conduits.
4. Division 100 Section "Conductors and Cables" for wires and cables.
5. Division 100 Section "Enclosed Switches and Circuit Breakers" for switch disconnectors.

1.3 SUBMITTALS

A. Technical Data: Include dimensions, ratings and data on features and components.

B. For Variable Frequency Drives: Submit manufacturer's performance data including dimensional drawings, customer connection drawings, power circuit diagrams, installation and maintenance manuals, warranty description, VFDs FLA rating, certification agency file numbers and catalogue information.

C. Shop and Installation Drawings: Submit for each motor control center, and prior to ordering materials and equipment, specified in this Section. Include dimensioned plans, elevations, and component lists. Show ratings, including short time and short-circuit ratings, and horizontal and vertical bus ampacities.

1. Complete technical schedule of features, characteristics, ratings, and factory settings on all motor starters, motor protection relays, sensing units, control accessories, etc.
2. Instructional details of equipment, particularly motor control centers and panels.
3. Installation details of motor control centers and panels and of control and sensing accessories.
4. Exact routing of power and control cables, wiring and conduits.
5. Feeder termination details at motor control centers, starters, motors, isolating switches, control and sensing accessories etc.
6. Wiring Diagrams: Interconnecting wiring diagrams (of all power and control circuits) pertinent to class and type specified for motor control center. Schematic diagram of each type of controller unit indicated.
7. Wiring Diagrams: Submit for approval detailed control wiring diagrams and a list of control equipment with descriptive literature.
8. Free hand field wiring diagrams or sketches will not be accepted.

D. Maintenance Data: For products to include in the maintenance manuals specified in Division 1.

1.4 QUALITY ASSURANCE

A. Source Limitations: Obtain motor control devices through one source from a single manufacturer.

B. Comply with the Following Standards: ANSI; NEMA; BS; VDE; DIN; IEC; UTE.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver in shipping splits of lengths that can be moved past obstructions in delivery path as indicated.

B. Store so condensation will not occur on or in motor control centers. Provide temporary heaters as required to prevent condensation.

C. Handle motor control centers according to Standards recommendations. Use factory-installed lifting provisions.

1.6 COORDINATION

A. Coordinate features of controllers and accessory devices with pilot devices and control circuits to which they connect.

B. Coordinate features, accessories, and functions of each motor controller with the ratings and characteristics of the supply circuit, the motor, the required control sequence, and the duty cycle of the motor and load.

1.7 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed, are packaged with protective covering for storage, and are identified with labels describing contents.

1. Spare Indicating Lights: Furnish 6 of each type required.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Approved Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

1. Allen-Bradley Co. (U.S.A.)
2. General Electric (U.S.A.)

3. Schneider Electric (France)
4. Siemens (Germany)

2.2 VARIABLE FREQUENCY DRIVE

A. Furnish complete variable frequency drives as specified herein for the fans and pumps designated to be variable speed. All standards and optional features shall be included within the VFD enclosure, unless otherwise specified. VFD enclosure shall be NEMA MC 1 with inlet air filters. Drive shall be mounted on a floor stand.

B. VFD shall convert three-phase, 50 hertz utility power to adjustable voltage and frequency, three phase power for stepless motor speed control from 10% to 100% of the motor's 50 hertz speed. Input voltage shall be as specified on the drawing schedules.

C. VFD shall include a converter and an inverter section. The converter section shall convert fixed frequency and voltage AC utility power to DC voltage. All VFDs shall include input line reactors or an isolation transformer as required. The inverter section of the VFD shall invert the DC voltage into a quality output waveform, with adjustable voltage and frequency for steeples motor speed control. The VFD shall maintain a constant V/Hz ratio. The VFD and options shall be tested to ANSI/UL.508. The complete drive, including all specified options, shall be listed by a nationally recognized testing agency such as UL or ETL.

D. Power line noise shall be limited to a voltage distortion factor and line notch as defined in IEEE 519 1981 Edition, "Guide for Harmonic Control and Reactive Compensation of Static Power Converters". The total voltage distortion shall not exceed 5 percent.

E. The VFD shall not emit radiated RFI in excess of the limitations set forth in the FCC Rules and Regulations, FCC Part 15 for Class A computing devices. The VFD shall carry a FCC compliance label. PWM type drives shall include RFI filters.

F. Motor noise as a result of the VFD shall be limited to 3 dB over across the line operation measured at 1 meter from the motor's centerline.

G. VFD's full load amp rating shall meet or exceed NFPA 70, NEC Table 430-150.

H. VFD's including communication port to communicate with control system

I. Protective Features will include:

1. Individual motor overload protection for each motor controlled.
2. Protection against input power under-voltage, over-voltage, and phase loss.
3. Protection against output current overload and instantaneous over-current.
4. Protection against over-temperature within the VFD enclosure.
5. Protection against over-voltage on the DC bus.
6. Protect VFD from sustained power of phase loss. Under-voltage trip activates automatically when line voltage drops more than 10 percent below rated input voltage.
7. Automatically reset faults due to under-voltage, over-voltage, phase loss, or over-temperature.

8. Protection against output short circuit and motor winding shorting to case faults, as defined by UL 508.
9. Status lights or digital display for indication of individual fault conditions.
10. Controller capable of operating without a motor or any other equipment connected to the drive output to facilitate start-up and troubleshooting.
11. Input line reactors shall be provided to minimize harmonics introduced to the AC line and to provide additional protection to AC line transients.

J. Interface Features for the VFD will include:

1. Door mounted Hand/Off/Auto selector switch to start and stop the VFD. In the Auto position, the VFD will start/stop from the controller. In the Hand position, the VFD will run regardless of the remote contact position.
2. Manual speed control capability.
3. Local/Remote selector switch. In the Remote position, motor speed is determined by the follower signal. In the local position, motor speed is determined by the manual speed control.
4. Power/On light to indicate that the VFD has tripped on a fault condition.
5. Digital meter with selector switch to indicate percent speed and percent load.
6. A set of form-C dry contacts, to indicate when the VFD is in the Run mode.
7. A set of form-C dry contacts, to indicate when the VFD is in the Fault mode.
8. A 0 to 10 V output signal to vary in direct proportion to the controller's speed.
9. VFD to have terminal strip and N.C. safety contacts such as freezstats, smoke alarms, etc. VFD to safety shut down in drive or bypass mode when contacts open.

K. Adjustments will include the following:

1. Maximum speed, adjustable 15 to 100 percent base speed.
2. Acceleration time, adjustable 3 to 60 seconds.
3. Deceleration time, adjustable 3 to 60 seconds with override circuit to prevent nuisance trips if decal time is set too short.
4. Current limit, adjustable 0 to 105 percent.
5. Overload trip set point.
6. Offset and gain to condition the input speed signal.

L. Service conditions will cover:

1. Ambient temperature, 0 to 50 deg C.
2. 0 to 95 percent relative humidity, non-condensing.
3. Elevation to 1,000 meters without derating.
4. AC line voltage variation, -10 to +10 percent of nominal.

M. Special features will include the following features in the VFD enclosure while maintaining its UL to ETL listing:

1. Manual by-pass shall provide all the circuitry necessary to transfer the motor from the VFD to the power line or from the line to the controller. The by-pass circuitry shall be mounted in a separate section of the VFD enclosure. Motor overload protection shall be provided in both drive and by-pass modes.
2. A door interlocked, pad lockable drive disconnect switch shall be provided to disconnect power from the VFD only (the disconnect shall be clearly marked as such).

3. A motor circuit protector, MCP, shall be provided as a means of disconnecting all power to both the VFD and by-pass circuits as well as providing short circuit and locked rotor protection to the motor while in the by-pass mode.
4. The disconnect and by-pass functions may be accomplished via disconnects, contractors and overloads, or with a four position Drive/Off/Line/Test switch with motor starter and by-pass fuses.

2.3 STARTERS

A. Starters for three phase motors to be magnetic type to automatically disconnect motor from power supply in case of supply failure, excessive voltage drop, overcurrent and lack of balance in phases. Overload trips to be provided for three phases.

B. Motor Data: Obtain from equipment supplier before ordering any motor starter, or check motor nameplate for full load current rating and allowable temperature rise in order to select proper overload thermal element for motor starter.

C. Short circuit protection device fitted to starter to be independent of controller and overload protection.

D. Control voltage for starters and control circuits is not to exceed 110 V.

E. Step Down Control Circuit Transformers: Two winding isolating type.

F. Control Circuit Protection: Use high rupturing capacity fuses or circuit breakers.

G. Auxiliary supply for controls other than from main power circuit, to be effectively isolated by auxiliary contacts on main isolator.

H. Control devices on starters to be as follows unless otherwise indicated or required by driven equipment: start stop push buttons, one red pilot light for "running", one group pilot light for "stopped" and one reset push button.

I. Starter type A for single phase motors not exceeding 1/2 HP to be surface or flush mounted, manual two pole toggle type, for non-reversing across the line starting, fitted with one overload element.

J. Starter type B for three phase motors not exceeding 10 HP to be direct on line, non reversing, magnetic type, with manual reset, 3 pole overload relay and low voltage protection, unless otherwise required by local regulations.

K. Starter type C for three phase motors over 10 HP, but not exceeding 50 HP, to be automatic star delta magnetic non reversing type, with 3 pole overload relay and low voltage protection, unless otherwise required by local regulations.

L. Starter type D for three phase motors over 50 HP to be multiple step auto transformer non reversing magnetic type, with 3 pole overload relay, low voltage protection, unless otherwise required by local regulations.

M. Individually mounted starters to be totally enclosed in sheet steel enclosure with baked enamel finish. Design is to suit location and application. It is to be impossible to open enclosure door unless isolator is in open position.

N. Nameplates: Starters and controls to have engraved nameplates identifying system or defining its function.

O. Contactors: Comply with IEC 947-4, utilization category AC3, and be 3-phase, 4-pole, magnetic type, 600 V rating, capable of interrupting at least ten times rated current inductive or non-inductive loads under normal service conditions and are to have replaceable main arcing contacts and arc quenching devices. Contactors are to withstand, without welding or burning of contacts, an inrush current of 20 times normal rating for 4 seconds upon closing and are to be capable of closing on the heaviest short-circuit of the system and withstand the short-circuit for period required by upstream short-circuit protective device to operate. Three N.O. and three N.C. spare contacts are to be provided on each contactor.

P. Starter Co-Ordination: Motor starter devices shall be of type 2 co-ordination to IEC 947-4-1.

Q. Solid-State, Reduced-Voltage Controller (soft starter): NEMA ICS 2, suitable for use with NEMA MG 1, Design B, polyphaser, medium induction motors.

1. Adjustable acceleration rate control utilizing voltage or current ramp, and adjustable starting torque control with up to 500 percent current limitation for 20 seconds.
2. Surge suppressor in solid-state power circuits providing 3-phase protection against damage from supply voltage surges 10 percent or more above nominal line voltage.
3. LED indicators showing motor and control status, including the following conditions:

    a. Control power available.
    b. Controller on.
    c. Overload trip.
    d. Loss of phase.
    e. Shorted silicon-controlled rectifier.

4. Automatic voltage-reduction controls to reduce voltage when motor is running at light load.
5. Motor running contactor operating automatically when full voltage is applied to motor.

2.4 COMBINATION STARTERS SWITCH DISCONNECTORS

A. Components to comprise magnetic starter switch disconnector and short circuit protection devices required by the Standards, in approved sheet metal enclosure to suit application.

B. Switch Disconnector Operating Mechanism: Quick make, quick break, with external operating handle mechanically interlocked with enclosure cover necessitating disconnecting switch to be in OFF position for access to inside of enclosure. Means are to be provided for by passing interlocks. Position of isolating switch to be clearly indicated on cover.

C. Short circuit protection gear to be HRC fused cartridges or molded case circuit breakers of appropriate current rupturing capacity. Switch disconnectors are not required if circuit breakers are used for the short circuit protection. In this case the circuit breaker will perform the disconnection function.

D. Operation of circuit breaker to be possible from outside of enclosure. Position of breaker ON/OFF/TRIPPED to be clearly indicated by position of handle.

2.5 PUSH BUTTONS

A. Push buttons to be one unit momentary contact START/STOP with normally open or normally closed contacts as required by wiring diagrams and with lockout attachments. Heads to be color-coded and STOP button to be protected. Push buttons controlling one piece of equipment to be housed in separate enclosure.

2.6 RELAYS

A. Relays to be multi-pole with normally open or normally closed contacts, electrically operated at 110 V maximum, and magnetically held. Contacts to be double break silvered type, interchangeable from normally open to normally closed without additional parts. Relays are to be rated at 10 A, 600 V.

2.7 CIRCUIT PROTECTORS AND SWITCHES

A. Motor Circuit Protector: Molded case, magnetic break type with adjustable instantaneous setting suitable for motor protection.

B. Motor circuit protectors are to be in compliance with IEC 947-2, utilization category B, sequence II (service capacity) for motor control centers and sequence III (ultimate capacity) for motor control panels and combination starters unless otherwise indicated on the drawings.

C. Molded Case Switch: Similar to circuit breakers but without overload/short circuit protection. Short time rating of switches is to be not less than the short circuit current at switch location for 3 cycles. Switches are to have a suitable self-override instantaneous protection and to be in compliance with IEC 947-3.

D. Main incoming switches to be equipped to provide earth fault under voltage and phase sequence protection through shunt trip coil. Earth fault detection and interruption to be time coordinated with those of main incoming breaker on main distribution board.

2.8 MOTOR CONTROL CENTER

A. Type: Totally enclosed, IP 42 for indoor installation, and IP 55 for outdoor installation and in wet areas (e.g. pump rooms), free-standing sectionalized type, modular, compartmented, form 3 to IEC 439 with separate withdrawable section for each motor starter and separate fixed section for main incoming breaker / switch and each outgoing feeder circuit breaker. Sections to be designed to allow other sections to be easily added or removed.

B. Construction: 2 mm thick sheet steel, adequately reinforced and braced for maximum rigidity, sand blasted, rust inhibited after fabrication and sprayed with one coat primer and two coats enamel internally and externally.

C. Components: Motor control center to include the following:

1. Main incoming circuit breaker or isolating switch as shown on the Drawings for terminating incoming supply cables and isolating the busbar system.
2. Main copper horizontal full-length busbars rated as main incoming circuit breaker or as shown on the Drawings.
3. Branch copper vertical full height busbars of adequate capacity to distribute power to each circuit breaker and starter served.
4. Neutral copper busbar rated at half capacity of main busbar and distributed throughout whole motor control center.
5. Earth copper busbars minimum 25 x 6 mm extending full length of motor control center.
6. One voltmeter with commutator, range 0-415 V.
7. Ammeters on main supply with necessary current transformers.
8. Starters, circuit breakers, push buttons, indicating lights, switches, relays, contactors and accessories as shown on the Drawings.
9. Interconnecting and interlock wiring.

D. Wiring: Motor control center wiring to be class II type B to NEMA ICS.

E. Bus bars to be adequately isolated and braced to sustain maximum possible short circuit current.

F. Compartment doors to be interlocked so that isolators or breakers must be in OFF position before door can be opened.

G. Spare Positions: Fully equipped cells, ready for connection to motors, are to be provided in adequate number.

H. Space Positions: Fully equipped cells ready to receive control unit are to be provided in adequate number. Space positions to have blank cover plates.

I. Starters, switches, other components and electrical devices to be clearly labeled in English as to number and function, with incised letters on black Bakelite with white laminated core. Labels to be permanently fixed under each component.

J. Incoming line connections to be made with solderless, terminal four bolt type clamps.

K. Labels: Starters, switches, electrical devices and accessories to be clearly labeled in English as to function and number. Labels to be permanently fixed under each component.

L. Schematic and wiring diagrams to be firmly fixed within motor control centre, showing each component and cross- referenced with component labels.

M. Submit for approval electrical schematic diagram of whole installation suggested layout of motor control centre, interior wiring details and complete technical literature on all proposed components, prior to fabrication or purchase.

2.9 MOTOR CONTROL PANELS

A. Type: Wall mounted or unit mounted, lockable type, IP 42 for indoor installation.

B. Construction: Minimum 1.5 mm thick hot-dip galvanized steel sheet, finished with one coat etch primer and one coat stove enamel internally and externally.

C. Panels installed outdoors and in wet areas to have weatherproof totally sealed water and dustproof IP 55 enclosures.

D. Components: Panels are to contain necessary breakers, starters, push button switches, selector switches, relays, indicating lights, interconnecting and interlock wiring and all devices and accessories required for automatic or manual operation of equipment as specified under equipment concerned.

E. Labels: Starters, switches, electrical devices and accessories to be clearly labeled in English as to function and number. Labels to be permanently fixed under each component.

F. Schematic and wiring diagrams to be mounted in permanent approved manner on inside of panel door. Diagrams are to show each component cross referenced with component labels.

2.10 CONTROL SWITCHES

A. Float Switch: Level operated, heavy duty, bracket mounted type, suitable for application in open tanks, complete with 178 mm spun copper float, brass rod, two stops, floor mounting stand, lever and counterweight. Switch to have oil tight and dust tight enclosure and 2 pole double throw silver contacts that open on liquid rise:

1. Man: Square D Company
2. Ref: Type BW 3

B. Pressure Switch: Industrial, heavy-duty bellows actuated type, suitable for water service, with contacts to close on falling pressure. Range to be 0.1 to 8 kg/cm2. Switch to be good for 1720 kPa operating pressure and to have 6 mm pipe tap bottom connection. It is to have oil tight and dust tight enclosure, single pole double throw contacts and setting adjustment:

1. Man: Square D Company
2. Ref: Type ACW-1

C. Low Suction Pressure Switch: Industrial, sensitive, low range, diaphragm actuated type, suitable for water service, with range of 2 to 20 kPa of falling pressure, preset at factory to 3 kPa. Switch to be good for 690 kPa operating pressure and to have 6 mm pipe tap bottom connection. It is to have oil tight and dust tight enclosure, single pole double throw contacts, range adjustment knob, sealing cap and range locking nut:

1. Man: Square D Company
2. Ref: Type AMW-1

PART 3 - EXECUTION

3.1 APPLICATIONS

A. Select features of each motor controller to coordinate with ratings and characteristics of supply circuit and motor; required control sequence; duty cycle of motor, drive, and load; and configuration of pilot device and control circuit affecting controller functions.

B. Select horsepower rating of controllers to suit motor controlled.

C. Push-Button Stations: In covers of magnetic controllers for manually started motors where indicated, start contact connected in parallel with sealing auxiliary contact for low-voltage protection.

D. Hand-off-automatic Selector Switches: In covers of manual and magnetic controllers of motors started and stopped by automatic controls or interlocks with other equipment.

3.2 INSTALLATION

A. Install motor control centers according to manufacturer's written instructions.

B. Anchor each motor control center assembly to steel-channel sills arranged and sized according to manufacturer's written instructions. Attach by tack welding or bolting. Level and grout sills flush with motor control center mounting surface.

C. Install motor control centers on concrete housekeeping bases conforming to Division 3 Section "Cast-in-Place Concrete."

D. Fuses: Install fuses in each fusible switch as indicated.

E. Power and Control Wiring: Run in separate conduits unless otherwise specified.

F. Rigid conduits are not to terminate in nor be fastened to a motor frame or base.

G. Flexible conduits to be used at motor connections. Allow sufficient slack to permit motor to slide over adjustable length of motor base.

H. Flexible Conduits: Length and radius to be sufficient to permit bending of feeder cables without damage to conductor or its insulation.

I. Flexible Conduits: Do not use in place of rigid conduits except at motor connections, unless otherwise specified.

J. Support conduit with conduit supports in an adequate approved manner.

K. Conduits are not to cross pipe or vent shafts, ducts or openings. They are to be run a minimum 100 mm away from pipes of non-electrical services.

L. Conduits: Install so that moisture can drain to lowest point. Provide screw plug at all low points for draining.

3.3 IDENTIFICATION

A. Identify field-installed wiring and components and provide warning signs according to Division 16 Section "Basic Electrical Materials and Methods."

B. Operating Instructions: Frame printed operating instructions for motor control centers, including control sequences, and emergency procedures. Fabricate frame of finished wood or metal and cover instructions with clear acrylic plastic. Mount on front of motor control centers.

C. Starters: Fix detailed wiring diagram inside enclosure cover to clearly indicate circuits.

D. Starters: Identify control and power wires either by distinctive colored insulation, engraved tags or other approved method.

3.4 CONTROL WIRING INSTALLATION

A. Bundle, train, and support wiring in enclosures.

B. Protect circuits with high rupturing capacity fuses or circuit breakers. Auxiliary supply for controls other than from main power circuit, to be effectively isolated by auxiliary contacts on main isolator.

C. Connect hand-off-automatic switch and other automatic control devices according to an indicated wiring diagram or one that is manufacturer approved, where available.

1. Connect selector switches to bypass only the manual and automatic control devices that have no safety functions when switch is in the hand position.
2. Connect selector switches with motor control circuit in both hand and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor-overload protectors.

3.5 EARTHING

A. Earth motors by connecting green insulated conductor from earthing bushing in starter to motor frame. Run earth conductor together with circuit wiring and terminate in motor terminal box, provided earth terminal in box is connected to motor frame. If this is not feasible, extend earth conductor through insulated bushed opening in terminal box and connect to motor base.

B. Earth equipment by connecting non-current carrying metal parts of system to earth source. Non-currents carrying metal parts include conduits, cable trays, outlet boxes, cabinets, enclosures, doors, grilles, and barriers protecting or shielding electrical equipment from direct access.

3.6 CONNECTIONS

A. Tighten motor control center bus joint, electrical connector, and terminal bolts according to manufacturer's published torque-tightening values.

3.7 FIELD QUALITY CONTROL

A. Testing: After installing motor control center and after electrical circuitry has been energized, demonstrate product capability and compliance with requirements.

1. Procedures: Perform recommended visual and mechanical inspection and electrical test. Certify compliance with test parameters.
2. Remove and replace malfunctioning units with new units, and retest.

B. Circuit Breakers: Co-ordinate earth fault detection and interruption with those of main incoming breaker on main distribution panel.

C. Pressure Switches: Test after installation to ensure dependable operation and correct setting.

D. Low Suction Pressure Switches: Test after installation to ensure dependable operation and correct setting.

3.8 CLEANING

A. Inspect interior and exterior of motor control centers. Remove paint splatters and other spots, dirt, and debris. Touch up scratches and mars of finish to match original finish. Clean devices internally, using methods and materials recommended by manufacturer.

3.9 DEMONSTRATION

A. Train Employer's maintenance personnel to adjust, operate, and maintain the system installation.

END OF SECTION 1009

SECTION 10010 - INTERIOR LIGHTING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Conditions of Contract, apply to this Section.

1.2 SUMMARY

A. This Section includes interior lighting fixtures, lighting fixtures mounted on exterior building surfaces, lamps, ballasts, emergency lighting units, mounting provisions and connection to circuit wiring and to corresponding lighting control equipment.

B. Related Sections include the following:

1. Division 100 Section "Basic Electrical Materials and Methods".

1.3 SUBMITTALS

A. Equipment Data: Submit data for approval including, but not limited to, the following:

1. Detailed literature on each fixture, lamp and control gear including manufacturer's name, catalogue number, rating, material specification, overall dimensions, operating characteristics and principles
2. Details of changes to standard fixtures for adaptation to condition of installation and to the Specification
3. Photometric data for lighting calculations including polar light distribution curves, coefficient of utilization, glare classification, efficiency, depreciation factors etc.
4. Dimensions of fixtures.
5. Certified results of laboratory tests for fixtures and lamps for photometric performance.
6. Emergency lighting unit battery and charger.
7. Fluorescent and high-intensity-discharge ballasts.
8. Types of lamps.

B. Shop and Construction Drawings: Submit Drawings for approval including, but not limited to, the following:

1. Exact position of each fixture on reflected ceiling plans, with indication of ceiling features, structural members, ducts, pipes and other fittings, as applicable and pertinent to the installation.
2. Installation details including suspension and mounting provisions.
3. Purpose made fixtures or lighting assemblies with full details.
4. Wiring details, circuit and panelboard references, special lighting control arrangements etc.

C. Samples: Submit fully equipped sample of each fixture type, modified if required, together with color and texture samples of each fixture.

D. Coordination Drawings: Reflected ceiling plans and sections drawn to scale and coordinating fixture installation with ceiling grid, ceiling-mounted items, and other components in the vicinity. Include work of all trades that is to be installed near lighting equipment.

E. Product Certificates: Signed by manufacturers of lighting fixtures certifying that products comply with requirements.

F. Dimming Ballast Compatibility Certificates: Signed by manufacturer of ballast certifying that ballasts are compatible with dimming systems and equipment with which they are used.

G. Maintenance Data: For lighting fixtures to include in maintenance manuals .

1.4 QUALITY ASSURANCE

A. Fixture Design and Standards: The Specification and the Drawings are a guide to the selection of lighting characteristics and lighting fixtures, giving general features of construction, materials, method of installation and conditions of operation. Unless otherwise specified, fixtures are to be manufacturer's standard series, designed and manufactured for the purpose and application required, generally in accordance with the Schedule of Lighting Fixtures and complying with IEC 60598 and CISPR 15.

B. Mockups: Provide lighting fixtures for room or module mockups. Install fixtures for mockups with power and control connections.

1. Obtain Engineer's approval of fixtures for mockups before starting installations.

2. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.
3. Remove mockups when directed. Fixtures may be reinstalled in the Work with approval of Engineer.
4. Approved fixtures in mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.5 COORDINATION

A. Design Layout: Fixture layout has been determined from photometric data of specified fixtures to achieve desired level and uniformity of illumination. Reflected ceiling plans are to be checked to ensure exact positions of fixtures with respect to structural members, ducts, pipes, other installations and ceiling panels/tiles, where required. Certain fixtures are shown in provisional positions, pending preparation of final equipment layout drawings. Such fixtures are to be located in coordination with final equipment layout so that illumination is as intended by the design.

B. Fixtures, Mounting Hardware, and Trim: Coordinate layout and installation of lighting fixtures with ceiling system and other construction.

1.6 EXTRA MATERIALS

A. Furnish extra materials described below that match product installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Lamps: 5 for every 100 of each type and rating installed. Furnish at least one of each type.
2. Plastic Diffusers and Lenses: 1 for every 100 of each type and rating installed. Furnish at least one of each type.
3. Battery and Charger Data: For emergency lighting units.
4. Ballasts: 1 for every 100 of each type and rating installed. Furnish at least one of each type.
5. Globes and Guards: 1 for every 20 of each type and rating installed. Furnish at least one of each type.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Products: Subject to compliance with requirements, provide one of the products indicated for each designation in the Lighting Fixture Schedule shown on Drawings.

1- PHILPS

2- CREE

3- GE

2.2 LIGHTING FIXTURE CONSTRUCTION - GENERAL

A. Generally: Construction and wiring of fixtures are to comply with the Regulations and Standards. Fixtures are to be fabricated, assembled and wired entirely at factory. Manufacturer's name, factory inspection stamp and official quality label is to be fixed to each fixture supplied.

B. Lighting Fixtures (Luminaires): Manufacturer's standard, as given in Lighting Fixture Schedules shown on the Drawings, or equal.

C. Sheet Steel Housings: Not less than 0.6 mm thick, and thicker when required by the Specification or the Standards.

D. Sheet Steel Reflectors: Not less than 0.5 mm thick.

E. Aluminum Reflectors: Not less than 0.7 mm thick, unless otherwise approved.

F. Fabrication: Metalwork is to be mitred, welded and ground smooth without tool marks or burrs. Flat metal parts are to be stiffened by forming grooves and edges during fabrication. Metal parts are to have finish free from irregularities.

G. Rust-proof Ferrous Base: Ferrous metal parts are to be bonderized (treated with corrosion resistant phosphate solution) and given an approved rust-inhibiting prime coat before application of final finish.

H. Finish for Non-Reflecting Metal Surfaces: Approved baked enamel paint. Paint color on fixture frames and trims are to be as specified or as selected by the Engineer.

I. Finish for Light Reflecting Surfaces: White baked enamel paint having reflection factor not less than 85%. Mirror reflectors, where specified, are to be highly polished, anodized aluminum with reflection factors not less than 97%.

J. Mechanical Resistance of Finish: After finish has been applied on steel surfaces and cured, it is to withstand a 6 mm radius bend without showing signs of cracking, peeling or loosening from base metal.

K. Resistance of Finish to Ultra-Violet: Finish is to withstand 72 hours exposure to an ultra-violet RS lamp placed 100 mm from surface without discoloring, hardening or warping, and is to retain the same reflection factor after exposure.

L. Heat Resistance: Finishes, wires and components inside fixtures are to be certified materials to resist the temperatures or other conditions encountered in the fixtures.

M. Wiring Inside Fixtures: Not less than 1.5 mm2, and insulated for 240 V application. Insulation is to have acceptable characteristics to resist maximum temperatures inside fixtures. Wiring is to be terminated on screw type, fixed, insulating, terminal blocks.

N. Hinges: Fixtures with visible frames and hinged diffusers are to have concealed hinges and catches, and stain-less steel retaining clips. Other alternative equally durable products may be submitted for approval.

O. Suspension Aligners: Provide for pendant fixtures for axial, vertical and horizontal alignment. Vertical adjustment is to be minimum 25 mm.

P. Recessed Fixtures: Construct to fit into suspended ceilings without distorting fixture or ceiling. Plaster rings are to be provided for plaster or concrete ceilings.

Q. Outdoor Fixtures: Non-ferrous metal or specially molded material for outdoor use.

R. Removal of parts for maintenance is to be possible without removing fixture housing.

2.3 LIGHT EMITTING DIODE (LED) LIGHTING SYSTEM SPECIFICATIONS

A. Light emitting diode shall be a solid state device embodying a p-n junction, emitting optical radiation when excited by an electric current. It shall be part of the LED module which is supplied as a light source. Output color consistency shall be guaranteed and have a color rendering index (CRI) greater than 80. LEDs shall have efficacy of 80 lumens per watt as a minimum guaranteed rated life shall be above 50000 hours.

B. Housing shall incorporate an adequate heat sink which ensures the overall fittings and the LEDs are kept relatively cool.

C. Electronic control gear for LED modules: high efficiency, high power factor, suitable for operation at the ambient conditions specified for the project. Control gear shall have a constant output current or constant output voltage over the whole wattage range independent of mains supply fluctuations as shown on drawings and sufficient for operating the number and wattage of LEDs connected. Guaranteed time of the control gear shall be above 50000 hours.

D. Control gear shall have electrical installation between primary and secondary sides. Secondary cables from the control gear to LED modules shall be provided by the LED supplier. Maximum length between control gear and LED module shall be as per manufacturer's recommendations.

E. LED control gear shall be protected against electric shock, accidental contact with live parts, short circuit, and overload and shall be earthed (protection class I).

F. Control gears shall comply with IEC 61347-1, IEC 61347-2-13 and IEC 62384 and shall meet the limits of main harmonic content as defined in IEC 61000-3-2 and comply with radio interface suppression limits defined in EN 55015 and immunity requirements of IEC 64547.
COMPLETE WITH ELECTRONIC CONTROL GEAR, AND LED LAMPS

PART 3 - EXECUTION

3.1 INSTALLATION

A. Generally: Install fixtures level, aligned and parallel or square to building lines and at uniform heights as shown on the Drawings or as approved by Engineer. Make final height adjustment after installation.

B. Fixture Support: Provide fixture and/or fixture outlet boxes with hangers, brackets and flanged bolted fittings, as necessary, to support weight of fixture. Submit details of hangers etc. and method of fastening

for approval. Rigidly secure fixtures mounted on outlet boxes to fixture studs. Install hooks or extension pieces, when required, for proper installation. Provide one point of support in addition to the outlet box fixture stud for individually mounted fixtures longer than 600 mm.

C. Stem Hangers: Provide two stem hangers for individually mounted pendant fixtures. Stems are to have suspension aligners and are to be of suitable length for suspending fixtures at required height.

D. Suspended Ceilings: If ceiling construction is unable to support weight of fixtures without strain or deformation, suspend fixtures directly from building structure.

E. Solid Ceilings: Coordinate dimensions of recesses in ceilings with exact fixture dimensions and structural elements.

F. Continuous Rows: Arrange fixtures so that individual fixture can be removed without dismantling remaining fixtures. Provide minimum spacing between fixtures.

G. Cover Plates: Install cover plates over fixture outlet box or opening in ceiling or structure when left unused.

H. Flush Recessed Fixtures: Install to completely eliminate light leakage within fixture and between fixture and adjacent finished surface.

I. Ventilation: Keep ventilation channels free after fixture is installed, if required by the design of the fixture.

J. Earth metal frames of as described in Division 16 Section "Grounding and Bonding".

K. Tightness: Ensure that enclosed fixtures are reasonably insect/dust tight when installed, and completely weather- proof for installations subject to weather conditions.

L. Lamps for Permanent Installation: Place new lamps in fixtures immediately prior to hand-over and when instructed by Engineer. Lamps used for temporary service are not to be used for final lamping of fixtures.

M. Fixtures: Set level, plumb, and square with ceiling and walls, and secure according to manufacturer's written instructions and approved submittal materials. Install lamps in each fixture.

N. Support for Fixtures in or on Grid-Type Suspended Ceilings: Use grid for support.

1. Install a minimum of four ceiling support system rods or wires for each fixture. Locate not more than 150 mm from fixture corners.
2. Support Clips: Fasten to fixtures and to ceiling grid members at or near each fixture corner.

3.2 INSPECTION AND TESTS ON SITE

A. Visual Inspection: Check neatness of installation, uniformity of equipment and nameplates etc.

B. Illumination Measurements: Taken at selected locations, to determine level and uniformity.

C. Operation: Check lighting installations for operation including control and regulation equipment.

D. Electrical Data: Measure power factor, current and voltage at start for installations with discharge lamps.

E. Inspect each installed fixture for damage. Replace damaged fixtures and components.

F. Advance Notice: Give dates and times for field tests.

G. Provide instruments to make and record test results.

H. Tests: As follows:

1. Verify normal operation of each fixture after installation.
2. Emergency Lighting: Interrupt electrical supply to demonstrate proper operation.
3. Verify normal transfer to battery source and retransfer to normal.
4. Report results in writing.

I. Malfunctioning Fixtures and Components: Replace or repair, then retest. Repeat procedure until units operate properly.

J. Corrosive Fixtures: Replace during warranty period.

3.3 CLEANING AND ADJUSTING

A. Clean fixtures internally and externally after installation. Use methods and materials recommended by manufacturer.

B. Adjust amiable fixtures to provide required light intensities.

END OF SECTION 10010

SECTION 10011 - EXTERIOR LIGHTING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Conditions of Contract, apply to this Section.

1.2 SUMMARY

A. This Section includes exterior lighting units with luminaires, lamps, ballasts, poles/support structures, and accessories and related power distribution and control, protective earthing and related builder's work including column foundations, cable pits, cable trenches and ductwork.

B. Related Sections include the following:

1. Division 100 Section "Basic Electrical Materials and Methods".
2. Division 100 Section "Interior Lighting" for interior fixtures, lamps, drivers, emergency lighting units, and accessories; and for exterior luminaires normally mounted on buildings.

1.3 DEFINITIONS

A. Lighting Unit: A luminaire or an assembly of luminaires complete with a common support, including pole, post, or other structure, and mounting and support accessories.

B. Luminaire (Light Fixture): A complete lighting device consisting of LED lamp(s) and drivers , when applicable, together with parts designed to distribute light, to position and protect lamps, and to connect LED lamps to power supply.

1.4 SUBMITTALS

A. Equipment Data: For each type of lighting unit indicated submit complete data for approval including, but not limited to, the following:

1. Detailed literature, in English, for each type of luminaire or fixture, lamp and control gear including manufacturer's name, catalogue number, rating, material specification, overall dimensions, operating characteristics and principles, and any modification to a standard product if applicable
2. Detailed specification and drawings for each column type including shape, base/mounting flanges, bolts, nuts etc, cross-sections, design criteria and calculations, brackets, finishes, provisions for cabling, cut-out or circuit-breaker etc.
3. Photometric data for lighting calculations including polar curves, coefficients of utilization, efficiency and depreciation factors.
4. Materials and dimensions of luminaires and poles.
5. Certified results of laboratory tests for fixtures and lamps for photometric performance.

B. Shop and Construction Drawings: Submit drawings for approval including, but not limited to, the following:

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

C. Samples: submit fully equipped sample of luminaire or other materials or components if required by Engineer.

D. Product Certificates: Signed by manufacturers of lighting units certifying that products comply with requirements.

E. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.

F. Maintenance Data: For lighting units to include in maintenance manuals .

1.5 QUALITY ASSURANCE

A. Standards: Luminaires generally are to comply with IEC 60598 and the applicable CISPR recommendations. Manufacturer is to verify compliance with these standards and the applicable local regulations and design standards.

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

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

1.6 DELIVERY, STORAGE, AND HANDLING OF POLES

A. Store poles on decay-resistant treated skids at least 300 mm above grade and vegetation. Support poles to prevent distortion and arrange to provide free air circulation.

B. Retain factory-applied pole wrappings on poles until just before pole installation. Handle poles with web fabric straps.

1.7 EXTRA MATERIALS

A. Spare Parts: Provide items necessary for maintenance, and up to 5% (or nearest whole unit) of installed quantities of each type of lamp, control gear, fuses, luminaire covers, special bolts or nuts, lamp-holders and the like which are subject to burning, breakage or failure.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Products: Subject to compliance with requirements, provide one of the products indicated for each designation in the Lighting Fixture Schedule shown on plans.

4- PHILPS

5- CREE

6- GE

2.2 LIGHTING COLUMNS

A. Construction: Columns are to be circular section, tapered, formed sheet steel, electrically welded, and of height specified. Columns up to 12-m height are to be one piece section. Columns above 12 m and up to 20-m height may be supplied in two piece sections, of the slip joint type with sufficient overlap to ensure correct vertical alignment of column after assembly. Columns are to have minimum wall thickness of 3 mm at base. Sheet steel is to have minimum rupturing resistance of 37 kg/mm2 and minimum yield strength of 24 kg/mm2.

B. Top of column is to be designed to receive single or double arm brackets or other arrangement required, supporting number of luminaires shown on the Drawings. Bracket arrangement is to be designed to ensure that failure, due to wind induced oscillations, does not occur and that rotation from desired alignment is not possible.

C. Column Design: Column cross-section, thickness of steel, joints, welds, bolts etc. are to be designed to withstand gust wind velocity of 160 km/hr blowing in the most unfavorable direction at a height 10 m above ground level, with column fully equipped. Fatigue of steel is in no case to exceed half elasticity

limit, taking into account dynamic stresses due to vibrations. Steel flange plate, of adequate thickness, is to be solidly welded onto lower edge of column as shown on the Drawings, and is to have specified number of holes for holding down bolts together with central cable access hole not less than 150 mm diameter.

D. Access door of weatherproof construction is to be positioned at column base and is to be suitably sized to insert and service the supply cable terminations and protective device. Door is to be flush fitting with retaining mechanism and positive locking arrangement with removable hexagonal key. Column is to be reinforced at door opening. Opposite each door, a non-hygroscopic baseboard of suitable size to accept appropriate equipment is to be fixed to inside of column by purpose-made brackets. Stainless steel earthing stud with washers and nuts is to be welded inside the column near the access door.

E. Finish: Welds are to be smooth with spatter removed, inside and outside surfaces of column are to be cleaned by pickling or blasting and are to be free of grease. Steel components of columns to be hot-dip galvanized after fabrication. Minimum thickness of zinc coating is to be 500 g/m2 on both inside and outside surfaces of column. Galvanizing is to be to NFA 91 121 or BS 729. Any damage to galvanizing is to be rectified during erection by wire brushing affected area and treating with approved rust converter to the satisfaction of Engineer. Flange plate and inside and outside of column base are to be coated with heavy bitumen paint prior to erection.

F. Protection and Wiring: Columns with one or two luminaires are to be connected over one phase and neutral. Columns with three or more luminaires are to be connected over 3 phases and neutral, unless otherwise shown on the Drawings. Bolted terminals and cable lugs are to be provided with 3 phases and neutral terminals, for incoming and outgoing 3 phase 4-wire cable, and of the sizes shown on Drawings. One circuit breaker, single pole 6 A is to be provided for each phase leading to a luminaire. Circuit breakers are to be compensated and rated for 50 deg. C ambient with interrupting capacity of at least 9 kA, and are to be mounted in weatherproof enclosure at baseboard. Wiring is to be PVC insulated 3 core or 4 core 85-deg. C conductor temperature. Cable is to be at least 4 mm2 copper conductor.

2.3 ROAD LIGHTING LUMINAIRES

A. Construction: Totally enclosed, dust protected and splash proof, conforming to at least IP 54 of IEC 60529, shock resistant and specially designed to house required lamps, electrical gear and accessories. Body is to be corrosion resistant, extruded, pressure die-cast or fabricated aluminum alloy.

B. Finish: Exposed metal parts of luminaires are to be factory finished, stove enameled, with suitable corrosion resisting paint capable of resisting heat emitted by lamp during continuous operation, and under full sunlight conditions. Color is to be agreed with Engineer.

C. Mirror Reflectors: 99.5% purity, glazed and anodized aluminum or die-cast, super-purity aluminum vapor-deposited, and coated with transparent layer of silicon protection against wiping.

D. Luminaire Protectors: Heat and shock resistant glass, mounted into suitable frame assembly fixed to body by captive screws, and secured by extra safety clamps to allow replacement of protector and reflector. Ozone resistant ethylene propylene or approved equivalent rubber is to ensure sealing of the front glass.

E. Lamp Sockets: High-grade porcelain, mounted in support brackets with provision to adjust lamps vertically and axially. Lamp support and locking system are to grip and prevent lamp movement in operation.

F. DRIVER and control-gear are to be mounted in luminaire in separate compartment isolated from LED lamp, and with encloterminal blocks fitted with quick-disconnect electrical leads. Where required, control gear is to be contained in the pre-wired box, having an enclosure of IP 65, and mounted on luminaire ring separately from luminaires. Control gear is to be plug in type for operation at 220 V, a.c. single phase, 50 Hz. Ballast is to be specially selected for particular type of lamps used, and lamps are to be able to start with at least +/-10% variation of nominal voltage and continue in normal operation with dips attaining 20% for four seconds. Control gear losses are not to exceed 10% of normal LED lamp wattage. RFI suppression device is to be provided. Power factor is to be compensated to at least 0.9 lagging.

G. HRC fuse cartridges, suitably rated and conforming to IEC 60269 or BS 88, are to be provided, complete with base, for protection of the luminaire. Fuse is to be rated to withstand starting current and is to be preferably located in control gear enclosure.

H. Terminal Blocks: Suitable screw-tunnel type, clearly marked with arrangement to facilitate maintenance, quick replacement and easy disconnection of individual components.

I. LED Lamps: Number and types shown on the Drawings and as described in Division 16 Section "Interior Lighting".

2.4 FLOODLIGHTS

A. Type: Totally enclosed type, weather, dust and shock resistant, IP 64 of IEC 60529.

B. Housing: High pressure die-cast aluminum alloy, closed on front by hinged framed protector highly resistant to thermal and mechanical shocks, and set in position by at least eight heavy duty stainless steel spring clamps with silicon sealing gasket. Enclosure is to be in accordance with IEC Publication 60598-2-5 and BS 4533-102.5, and is to be suitable for operation in an ambient temperature of 70 deg. C.

C. Reflectors: High purity (over 99% reflectance) anodized aluminum, secured in precision aligned internal tracks to provide beam distribution required.

D. Connection box is to be located at rear of floodlight body with gland connections to accept 4 mm2 PVC/PVC three core cable. Lamp and control gear to be mounted in two separate and isolated compartments.

E. Control Gear: Plug-in type, 220V, 50 Hz, power factor compensated to at least 0.9 lagging. Ballasts and ignitors are to be type specially adapted for make of lamps selected. Ignitors are to be electronic thyristor type. Lamp is to be able to start with at least +/-10% line voltage, and with normal operation dips up to 20% for four seconds. Compensation is to ensure that there is no large increase in operating current during starting. Control gear losses are not to exceed 10%. Cables for internal wiring in control gear compartments are to be single core 2.5 mm2 copper conductors with high temperature insulation and sheath.

F. Finish: Exposed metal parts of floodlights are to be painted with corrosion and heat resistant paint, resisting operating temperatures attained in direct sunlight while lamp is burning.

G. Mounting: Floodlights are to be located as shown on the Drawings and mounted on specially designed brackets to allow swiveling in any desired direction and locking firmly in final position. Protractor scale is to be provided for accurate setting.

H. Earthing Terminals: Bolted earthing terminal is to be provided in each fitting.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Equipment: Install equipment to be readily accessible for operation, maintenance and repair. Minor deviations from the Drawings may be made to accomplish this but no changes are to be made without the approval of Engineer.

B. Column Bases: Install columns on concrete bases as detailed on the Drawings. Before commencement of construction, ensure that bases are suitable for column installation.

C. Holding Down and Plumb Adjusting Nuts, Washers, Locknuts or Nyloc Nuts: Stainless steel or cadmium plated.

D. Columns: Erect columns so that luminaires are located on a line parallel to theoretical profile of road. Alignment of columns, both horizontally and vertically, is to be secured to the satisfaction of Engineer. Brackets are to be set at 90 degrees to longitudinal axis of road.

E. Install poles as follows:

1. Use web fabric slings (not chain or cable) to raise and set poles.
2. Mount pole to foundation with leveling nuts, and tighten top nuts to torque level recommended by pole manufacturer.
3. Secure poles level, plumb, and square.
4. Grout void between pole base and foundation. Use non-shrinking or expanding concrete grout firmly packed in entire void space.
5. Use a short piece of 13-mm diameter pipe to make a drain hole through grout. Arrange to drain condensation from interior of pole.

F. Luminaire Attachment with Adjustable Features or Aiming: Attach luminaires and supports to allow aiming for indicated light distribution.

G. Mounting Adjustments: After demonstrating to Engineer that specified lighting requirements have been met, carry out final setting and locking in position of the floodlights.

H. Luminaire Attachment: Fasten to indicated structural supports.

I. Lamp luminaires with indicated lamps according to manufacturer's written instructions. Replace malfunctioning lamps.

J. Cabling Conduits and Ductwork: Carry out in accordance with Division 16 Section "Conductors and Cabling". Cable ducts are to be directly buried except at crossings with other service work or roads.

3.2 INSPECTION AND TESTS ON SITE

A. Visual inspection is to include inspection of condition of each piece of equipment, quality of workmanship, alignment, perpendicularity, labeling and the like, all in conformance with the Specification.

B. Insulation resistance and continuity tests are to be carried out on each circuit and piece of equipment before energization, with circuit breakers in the open position and lamps not installed.

C. Operational tests are to be carried out on all circuit breakers and control gear, with lamps installed, including recording voltage at terminals of ballasts on final columns of each circuit and at distribution panel or the like.

D. Performance tests are to be carried out after 100 hours normal operation, and are to include measurement of lighting and uniformity levels on required illuminated surfaces.

E. Other tests are to be carried out as required by the Engineer to verify conformity with the Specification.

F. Earthing resistance tests are to include measurement of earth electrode resistance at final points of circuits and continuity of protective conductors.

G. Results of tests are to be recorded on site and signed by witnessing parties.

H. Provide instruments to make and record test results.

I. Tests and Observations: Verify normal operation of lighting units after installing luminaires and energizing circuits with normal power source, and as follows:

1. Measure light intensities at night if specific illumination performance is indicated. Use calibrated photometers.
2. Check intensity and uniformity of illumination.
3. Check excessively noisy ballasts.

J. Prepare a written report of tests, inspections, observations and verifications indicating and interpreting results.

K. Malfunctioning Fixtures and Components: Replace or repair, then retest. Repeat procedure until units operate properly.

3.3 CONNECTIONS

A. Ground Equipment:

1. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values.

B. Ground metal poles/support structures according to Division 100 Section "Grounding and Bonding."

1. Nonmetallic Poles: Ground metallic components of lighting units and foundations. Connect luminaires to grounding system with conductor as shown on plans or in accordance with Regulations.

3.4 CLEANING AND ADJUSTING

A. Clean units after installation. Use methods and materials recommended by manufacturer.

B. Adjust amiable luminaires and luminaires with adjustable lamp position to provide required light distributions and intensities.

END OF SECTION 10011

SECTION 10012 - FIRE ALARM SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Conditions of Contract, apply to this Section.

1.2 SUMMARY

A. This Section includes fire alarm systems with manual stations, detectors, signal equipment, controls, and devices.

B. Related Sections include the following:

1. Division 100 Section "Basic Electrical Materials and Methods".
2. Division 100Section "Grounding and Bonding".
3. Division 100 Section "Conductors and Cables" for fire alarm system power wiring.
4. Division 100 Section "Raceways and Boxes" for fire alarm system wiring method and enclosure requirements.

1.3 DEFINITIONS

A. MFAC: Main fire alarm control panel.

B. CM: Control module.

C. MM: Monitor module.

D. PC: Personal computer.

1.4 SYSTEM DESCRIPTION

A. General: Non-coded, addressable-analog system with manual and automatic alarm initiation; automatic sensitivity control of certain smoke detectors; and multiplexed signal transmission dedicated to fire alarm service only.

B. Scope of Work: Provide the following:

1. Main fire alarm cabinet, manual stations, automatic fire detectors, interface with other systems, wiring, wire-ways and all accessories to form a complete system.
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1.5 SUBMITTALS

A. Product Data: For each type of product indicated.

1. Detectors characteristic curves of coverage area against ceiling height and air movement speed.
2. Personal computer including dual processor type and speed, auxiliaries, software-package, printer and the like.

B. Shop Drawings: Include dimensioned plans and elevation views of components. Show access and workspace requirements. Include at least the following:

1. Detailed floor layouts showing all outlets with label reference and exact routing of cabling and wire ways.
2. Detailed system schematic diagram. Differentiate between manufacturer-installed and field-installed wiring. Include diagrams for equipment and for system with all terminals and interconnections identified.
3. Detailed equipment layout in rooms and closets including elevations and typical installation details.
4. Show details of graphic annunciator.
5. Battery: Sizing calculations.
6. Device Address List: Coordinate with final system programming and labeling.
7. System Operation Description: Detailed description for this Project, including method of operation and supervision of each type of circuit and sequence of operations for manually and automatically initiated system inputs and outputs. Manufacturer's standard descriptions for generic systems are not acceptable.
8. Cause and Effect Matrix: Show in a matrix format, the effect of every initiating device on the MFAC, notification devices and all system peripherals.

C. Coordination Drawings: Plans, sections, and elevations drawn to scale and coordinating installation of smoke detectors in ducts and access to them. Show the following near each duct smoke provision of detector installation:

1. Size and location of ducts, including lining.
2. Size and location of piping.
3. Size and arrangement of structural elements.
4. Size and location of duct smoke detector, including air-sampling elements.

D. Qualification Data: For firms and persons specified in "Quality Assurance" Article to demonstrate their capabilities and experience. Include lists of completed projects with project names and addresses, names and addresses of architects/engineers and owners, and other information specified or required by Engineer.

E. Operating Instructions: For mounting at the MFAC.

F. Product Certificates: Signed by manufacturers of system components certifying that products furnished comply with requirements.

G. Installer Certificates: Signed by manufacturer certifying that installers comply with requirements.

H. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.

I. Maintenance Data: For fire alarm systems to include in maintenance manuals specified in Division 1.

J. Submissions to Authorities Having Jurisdiction: In addition to distribution requirements for Submittals specified in Division 1 Section "Submittal Procedures," make an identical submission to authorities having jurisdiction. Include copies of annotated Contract Drawings as needed to depict component locations to facilitate review. Resubmit if required to make clarifications or revisions to obtain approval. On receipt of comments from authorities having jurisdiction, submit them to Engineer for review.

K. Sound Levels: Measure and submit audible sound levels. Verify that 15 decibels (dB) above ambient noise levels or 5 dB above the maximum sound level that occurs at the location for 60 seconds or more, but not greater than 120 dB, are achieved.

L. Test Results and Certificate of Completion: Comply with specified Standard.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: An experienced installer who is an authorized representative of the fire alarm system manufacturer for both installation and maintenance of units required for this Project.

1. Experience: Minimum 5 years.
2. Demonstrate that installer has satisfactorily completed at least two system installations similar in design and extent to that indicated for this Project, and with a record of successful in-service performance.

B. Manufacturer Qualifications: A firm experienced in manufacturing systems similar to those indicated for this Project and with a record of successful in-service performance.

C. Source Limitations: Obtain fire alarm system components through one source from a single manufacturer.

D. Compliance with Local Requirements: Comply with applicable building code, local ordinances and regulations, and requirements of authorities having jurisdiction.

E. Codes and Standards: Comply with the following:

1. NFPA 70, "National Electric al Code".
2. NFPA 72, "National Fire Alarm Code".
3. NFPA 101, "Code for Safety to Life from Fire in Buildings and Structures".

1.7 EXTRA MATERIALS

A. Furnish extra materials described below that match product installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Lamps for Remote Indicating Lamp Units: Quantity equal to 2 percent of amount installed, but not less than one unit.
2. Lamps for Strobe Units: Quantity equal to 2 percent of amount installed, but not less than one unit.
3. Smoke Detectors, Fire Detectors, and Flame Detectors: Quantity equal to 2 percent of amount of each type installed, but not less than one unit of each type.
4. Detector Bases: Quantity equal to 1 percent of amount of each type installed, but not less than one unit of each type.
5. Printer Ribbons: Six spares.
6. Keys and Tools: One extra set for access to locked and tamper-proofed components.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Approved Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

1. Cerberus (Switzerland).
2. Edwards Systems Technology (Canada).
3. Esser (Germany).
4. Gent (UK).
5. Honeywell, Inc. (USA).
6. Notifier (USA).
7. Pyrotronics (USA).
8. Siemens (Germany).
9. Simplex Time Recorder Co. (USA).
10. Thorn (UK).

2.2 FUNCTIONAL DESCRIPTION OF SYSTEM

A. Control of System: By the MFAC.

B. System Supervision: Automatically detect and report open circuit, short circuit, and ground fault of wiring for initiating device, signaling line, and notification-appliance circuits.

C. Priority of Signals: Automatic alarm response functions resulting from an alarm signal from one zone or device are not altered by subsequent alarm, supervisory, or trouble signals. An alarm signal is the highest priority. Supervisory and trouble signals have second- and third-level priority. Higher-priority signals take precedence over signals of lower priority, even when the lower-priority condition occurs first. Annunciate and display all alarm, supervisory, and trouble signals regardless of priority or order received.

D. Noninterference: A signal on one zone shall not prevent the receipt of signals from other zones.

E. System Reset: All zones are manually re-settable from the MFAC after initiating devices are restored to normal.

F. Transmission to Remote Alarm Receiving Station: Automatically route alarm, supervisory, and trouble signals to a remote alarm station by means of a digital alarm communicator transmitter and telephone lines.

G. Transmission to Remote Alarm Receiving Station: Automatically route alarm, supervisory, and trouble signals to a remote alarm receiving station by means of a radio alarm transmitter.

H. System Alarm Capability during Circuit Fault Conditions: System wiring and circuit arrangement prevent alarm capability reduction when a single ground occurs in an initiating device circuit, signal line circuit, or notification-appliance circuit.

1. Initiating Device Circuits (IDC) System Wiring: Class B, Style C.
2. Signaling Line Circuits (SLC) System Wiring: Class B, Style 4.
3. Notification Appliance Circuits (NAC): Class B, Style Y.

I. System Alarm Capability during Circuit Fault Conditions: System wiring and circuit arrangement prevent alarm capability reduction when a single ground or open circuit occurs in an initiating device circuit, signal line circuit, or notification-appliance circuit.

1. Initiating Device Circuits (IDC) System Wiring: Class A, Style D.
2. Signaling Line Circuits (SLC) System Wiring: Class A, Style 6.
3. Notification Appliance Circuits (NAC): Class A, Style Z.

J. System Alarm Capability during Circuit Fault Conditions: System wiring and circuit arrangement prevent alarm capability reduction when an open circuit, ground or wire-to-wire short occurs, or an open circuit and a ground occur at the same time in an initiating device circuit, signal line circuit, or notification-appliance circuit.

1. Initiating Device Circuits (IDC) System Wiring: Class A, Style D or E.
2. Signaling Line Circuits (SLC) System Wiring: Class A, Style 7.
3. Notification Appliance Circuits (NAC): Class A, Style Z.

K. Loss of primary power at the MFAC initiates a trouble signal at the MFAC. The MFAC indicates when the fire alarm system is operating on the secondary power supply.

L. Loss of primary power at the MFAC initiates a trouble signal at the MFAC and the annunciator. An emergency power light is illuminated at both locations when the system is operating on the secondary power supply.

M. Basic Alarm Performance Requirements: Unless otherwise indicated, operation of a manual station, automatic alarm operation of a smoke or flame or heat detector**,** or operation of a sprinkler flow device initiates the following:

1. Activation of presignal at MFAC.

    a. Local alarm in the control unit for the period of a programmable time T1.
    b. During this delay time (T1), an internal (staff) alarm (stage 1) only is to be given. If the alarm is not acknowledged before timer T1 runs out, this is to result in notification-appliance operation (stage 2) as detailed in subparagraph 2.2M.2 below.
    c. If the alarm is acknowledged while T1 is still running, T1 is to be reset and a programmable timer T2 is to be started. T2 is to delay the notification-appliance operation (stage2) further, and so provide time for human investigation of the alarm cause.
    d. If no reset action takes place before T2 runs out, notification-appliance operation (stage 2) is to be given.

2. Notification-appliance operation.

    a. Alarm signal in floor of incidence floors above and below; alert signal in remaining parts of building.
    b. Alarm throughout the building.
    c. Activation of visual strobes.

3. Identification at the MFAC of the zone originating the alarm.
4. Identification at the MFAC of the device originating the alarm.
5. Transmission of an alarm signal to the remote alarm receiving station.
6. Unlocking of electric door locks in designated egress paths.
7. Release of fire and smoke doors held open by magnetic door holders.
8. Recall of elevators.
9. Shut off public address and music equipment.
10. Shutdown of fans and other air-handling equipment serving zone when alarm was initiated.
11. Closing of smoke dampers in air ducts of system serving zone where alarm was initiated.
12. Recording of the event in the system memory.
13. Recording of the event by the system printer.

N. Alarm Silencing, System Reset and Indication: Controlled by switches in the MFAC.

1. Silencing-switch operation halts alarm operation of notification appliances and activate an "alarm silence" light. Display of identity of the alarm zone or device is retained.

2. Subsequent alarm signals, from other devices or zones, shall reactivate notification appliances, until silencing switch is operated again.
3. When alarm-initiating devices return to normal and system reset switch is operated, notification appliances operate again until alarm silence switch is reset.

O. Water-flow alarm switch operation initiates the following:

1. Notification-appliance operation.
2. Flashing of the device location indicating light for the device that has operated.

P. Water-flow alarm for connection to sprinkler in an elevator shaft and elevator machine room shuts down elevators associated with the location without time delay.

1. A field-mounted relay actuated by the fire detector or the MFAC closes the shunt trip circuit and operates building notification appliances and annunciator.

Q. Smoke detection for zones or detectors with alarm verification initiates the following:

1. Audible and visible indication of an "alarm verification" signal at the MFAC.
2. Activation of a listed and approved "alarm verification" sequence at the MFAC and the detector.
3. Recording of the event by the system printer.
4. General alarm if the alarm is verified.
5. Cancellation of the MFAC indication and system reset if the alarm is not verified.

R. Sprinkler valve-tamper switch operation initiates the following:

1. A supervisory, audible, and visible "valve-tamper" signal indication at the MFAC and the annunciator.
2. Flashing of the device location-indicating light for the device that has operated.
3. Recording of the event by the system printer.
4. Transmission of supervisory signal to remote alarm receiving station.

S. Fire-pump power failure, including a dead-phase or phase-reversal condition, initiates the following:

1. A supervisory, audible, and visible "fire-pump power failure" signal indication at the MFAC.
2. Recording of the event by the system printer.
3. Transmission of trouble signal to remote alarm receiving station.

T. Low-air-pressure switch operation on a dry-pipe or preaction sprinkler system initiates the following:

1. A supervisory, audible, and visible "sprinkler trouble" signal indication at the MFAC and the annunciator.
2. Flashing of the device location indicating light for the device that has operated.
3. Recording of the event by the system printer.
4. Transmission of trouble signal to remote central station.

U. Remote Detector Sensitivity Adjustment: Manipulation of controls at the MFAC causes the selection of specific addressable smoke detectors for adjustment, display of their current status and sensitivity settings, and control of changes in those settings. Same controls can be used to program repetitive, scheduled, automated changes in sensitivity of specific detectors. Sensitivity adjustments and sensitivity-adjustment schedule changes are recorded in system memory and are printed out by the system printer.

V. Removal of an alarm-initiating device or a notification appliance initiates the following:

1. A "trouble" signal indication at the MFAC and the annunciator for the device or zone involved.

2. Recording of the event by the system printer.
3. Transmission of trouble signal to remote alarm receiving station.

W. Printout of Events: On receipt of the signal, print alarm, supervisory, and trouble events. Identify zone, device, and function. Include type of signal (alarm, supervisory, or trouble), and date and time of occurrence. Differentiate alarm signals from all other printed indications. Also print system-reset event, including the same information for device, location, date, and time. Commands initiate the printout of a list of existing alarm, supervisory, and trouble conditions in the system and a historical log of events.

X. MFAC Alphanumeric Display: Plain-English-language descriptions of alarm, supervisory, and trouble events; and addresses and locations of alarm-initiating or supervisory devices originating the report. Display monitoring actions, system and component status, system commands, programming information, and data from the system's historical memory.

2.3 MANUAL STATIONS

A. Description: Fabricated of metal or plastic, and finished in red with molded, raised-letter operating instructions of contrasting color.

1. Single-action mechanism initiates an alarm, break glass type.
2. Double-action mechanism requires two actions to initiate an alarm.
3. Station Reset: Key or wrench operated; double-pole, double-throw; switch rated for the voltage and current at which it operates.
4. Indoors Protective Shield: Factory-fabricated clear plastic enclosure, hinged at the top to permit lifting for access to initiate an alarm. Lifting the cover actuates an integral battery-powered audible horn intended to discourage false alarm operation.
5. Weatherproof Protective Shield: Factory-fabricated clear plastic enclosure, hinged at the top to permit lifting for access to initiate an alarm.
6. Integral Addressable Module: Arranged to communicate manual-station status (normal, alarm, or trouble) to the MFAC.

2.4 SMOKE DETECTORS

A. General: Include the following features:

1. Operating Voltage: 24-V dc, nominal.
2. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
3. Plug-in Arrangement: Detector and associated electronic components are mounted in a module that connects in a tamper-resistant manner to a fixed base with a twist-locking plug connection. Terminals in the fixed base accept building wiring.
4. Integral Visual-Indicating Light: LED type. Indicates detector has operated.
5. Sensitivity: Can be tested and adjusted in-place after installation.
6. Mounting: Surface or semi-recessed ceiling mounted type, located as shown on Drawings, with head removable from fixed twist-lock base. Removal of detector head is to interrupt supervisory circuit and cause trouble signal at control panel. Normal flat surface coverage is to be over 100 m2 at mounting height of 6 m.
7. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to the MFAC.
8. Circuitry for two-way communication with the MFAC: Each time the detector is polled, it is to communicate its type (ionization, optical etc.) and an analogue/digitally-encoded value corresponding to its sensitivity and status with microcomputer processing in the control unit. Detector is to be automatically addressed by its location in the signaling loop.

9. Remote Controllability: Unless otherwise indicated, detectors are analog-addressable type, individually monitored at the MFAC for calibration, sensitivity, and alarm condition, and individually adjustable for sensitivity from the MFAC.

B. Photoelectric Smoke Detectors: Include the following features:

1. Sensor: LED or infrared light source with matching silicon-cell receiver.
2. Detector Sensitivity: Between 0.008 and 0.011 percent/mm smoke obscuration.

C. Beam-Type Smoke Detector: Each detector consists of a separate transmitter and receiver with the following features:

1. Adjustable Sensitivity: More than a six-level range, minimum.
2. Linear Range of Coverage: 180 m minimum.
3. Tamper Switch: Initiates trouble signal at the central MFAC when either transmitter or receiver is disturbed.
4. Separate Color-Coded LEDs: Indicate normal, alarm, and trouble status. Any detector trouble, including power loss, is reported to the central MFAC as a composite "trouble" signal.

D. Duct Smoke Detector: Ionization type.

1. Sampling Tube: Design and dimensions as recommended by the manufacturer for the specific duct size, air velocity, and installation conditions where applied.
2. Relay Fan Shutdown: Rated to interrupt fan motor-control circuit.

2.5 OTHER DETECTORS

A. Heat Detector, Combination Type: Actuated by either a fixed temperature of 57 deg C or rate of rise of temperature that exceeds 8.3 deg C per minute, unless otherwise indicated.

1. Mounting: Adapter plate for outlet box mounting.
2. Mounting: Plug-in base, interchangeable with smoke detector bases.
3. Mounting: Surface or semi-recessed ceiling mounted type, located as shown on Drawings, with head removable from fixed twist-lock base. Removal of detector head is to interrupt supervisory circuit and cause trouble signal at control panel. Normal flat surface coverage is to be over 50 m2.
4. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to the MFAC.
5. Circuitry for two-way communication with the MFAC: Each time the detector is polled, it is to communicate its type and an analogue/digitally-encoded value corresponding to its sensitivity and status with microcomputer processing in the control unit. Detector is to be automatically addressed by its location in the signaling loop.

B. Heat Detector, Fixed-Temperature Type: Actuated by temperature that exceeds a fixed temperature of 88 deg C.

1. Mounting: Adapter plate for outlet box mounting.
2. Mounting: Plug-in base, interchangeable with smoke detector bases.
3. Mounting: Surface or semi-recessed ceiling mounted type, located as shown on Drawings, with head removable from fixed twist-lock base. Removal of detector head is to interrupt supervisory circuit and cause trouble signal at control panel. Normal flat surface coverage is to be over 50 m2.
4. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to the MFAC.
5. Circuitry for two-way communication with the MFAC: Each time the detector is polled, it is to communicate its type and an analogue/digitally-encoded value corresponding to its sensitivity and status with

microcomputer processing in the control unit. Detector is to be automatically addressed by its location in the signaling loop.

C. Continuous Linear Heat-Detector System: Consists of detector cable and control unit.

1. Detector Cable: Rated detection temperature 68 deg C. Listed for "regular" service and a standard environment. Cable includes two steel actuator wires twisted together with spring pressure, wrapped with protective tape, and finished with PVC outer sheath. Each actuator wire is insulated with heat-sensitive material that reacts with heat to allow the cable twist pressure to short circuit wires at the location of elevated temperature.
2. Control Panel: Two-zone or multizone unit as indicated. Provides same system power supply, supervision, and alarm features as specified for the central MFAC.
3. Signals to the Central MFAC: Any type of local system trouble is reported to the central MFAC as a composite "trouble" signal. Alarms on each detection zone are individually reported to the central MFAC as separately identified zones.
4. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to the MFAC.
5. Circuitry for two-way communication with the MFAC: Each time the detector is polled, it is to communicate its type and an analogue/digitally-encoded value corresponding to its sensitivity and status with microcomputer processing in the control unit. Detector is to be automatically addressed by its location in the signaling loop.

2.6 NOTIFICATION APPLIANCES

A. Description: Equip for mounting as indicated and have screw terminals for system connections.

1. Combination Devices: Factory-integrated audible and visible devices in a single-mounting assembly.

B. Bells: Electric-vibrating, 24-V dc, under-dome type; with provision for housing the operating mechanism behind the bell. When operating, bells provide a sound-pressure level of 94 dB, measured 3 m from the bell. 254-mm size, unless otherwise indicated. Bells are weatherproof where indicated.

C. Visible Alarm Devices: Xenon strobe lights with clear or nominal white polycarbonate lens. Mount lens on an aluminum faceplate. The word "FIRE" is engraved in minimum 25-mm- high letters on the lens.

1. Rated Light Output: 110 candela.
2. Strobe Leads: Factory connected to screw terminals.

2.7 MAGNETIC DOOR HOLDERS

A. Description: Units are equipped for wall or floor mounting as indicated and are complete with matching doorplate.

1. Electromagnet: Requires no more than 3 W to develop 111-N holding force.
2. Wall-Mounted Units: Flush mounted, unless otherwise indicated.
3. Rating: 24-V ac or dc.
4. Rating: 220-V ac.

B. Material and Finish: Match door hardware.

2.8 CENTRAL MFAC

A. Cabinet: Lockable steel enclosure. Arrange interior components so operations required for testing or for normal maintenance of the system are performed from the front of the enclosure. If more than one unit is required to form a complete control panel, fabricate with matching modular unit enclosure to accommodate components and to allow ample gutter space for field wiring and interconnecting panels.

1. Identify each enclosure with an engraved, red, laminated, phenolic-resin nameplate with lettering not less than 25 mm high. Identify individual components and modules within cabinets with permanent labels.
2. Mounting: Surface.

B. Alarm and Supervisory Systems: Separate and independent in the MFAC. Alarm-initiating zone boards consist of plug-in cards. Construction requiring removal of field wiring for module replacement is unacceptable.

C. Control Modules: Include types and capacities required to perform all functions of fire alarm systems.

D. Indications: Local, visible, and audible signals announce alarm, supervisory, and trouble conditions. Each type of audible alarm has a different sound.

E. Alphanumeric Display and System Controls: Arranged for interface between human operator at the MFAC and addressable system components, including annunciation and supervision. Display alarm, supervisory, and component status messages and the programming and control menu.

1. Display: Liquid-crystal type, 80 characters minimum.
2. Keypad: Arranged to permit entry and execution of programming, display, and control commands.

F. Instructions: Printed or typewritten instruction card mounted behind a plastic or glass cover in a stainless steel or aluminum frame. Include interpretation and describe appropriate response for displays and signals. Briefly describe the functional operation of the system under normal, alarm, and trouble conditions.

G. Interface with the BACS: Provide software protocol to communicate and interface all information to the BACS system. All controls in case of fire are to remain with the fire alarm system.

2.9 EMERGENCY POWER SUPPLY

A. General: Components include valve-regulated, recombinant lead acid battery; charger; and an automatic transfer switch.

1. Battery Nominal Life Expectancy: 10 years, minimum.

B. Battery Charger: Solid-state, fully automatic, variable-charging-rate type. Provide capacity for 150 percent of the connected system load while maintaining batteries at full charge. If batteries are fully discharge d, the charger recharges them completely within four hours. Charger output is supervised as part of system power supply supervision.

C. Integral Automatic Transfer Switch: Transfers the load to the battery without loss of signals or status indications when normal power fails.

2.10 ADDRESSABLE INTERFACE DEVICE

A. Description: Microelectronic monitor module listed for use in providing a multiplex system address for listed fire and sprinkler alarm-initiating devices with normally open contacts.

B. Integral Relay: Capable of providing a direct signal to the elevator controller to initiate elevator recall or to a circuit-breaker shunt trip for power shutdown.

2.11 DIGITAL ALARM COMMUNICATOR TRANSMITTER

A. Functional Performance: Unit receives an alarm, supervisory, or trouble signal from the MFAC panel, and automatically captures one or two telephone lines and dials a preset number for a remote central station. When contact is made with the central station(s), the signal is transmitted. The unit supervises up to two telephone lines. Where supervising two lines, if service on either line is interrupted for longer than 45 seconds, the unit initiates a local trouble signal and transmits a signal indicating loss of telephone line to the remote alarm receiving station over the remaining line. When telephone service is restored, unit automatically reports that event to the central station. If service is lost on both telephone lines, the local trouble signal is initiated.

B. Secondary Power: Integral rechargeable battery and automatic charger.

C. Self-Test: Conducted automatically every 24 hours with report transmitted to central station.

2.12 SYSTEM PRINTER

A. Description: Listed and labeled as an integral part of the fire alarm system.

B. The system is to have a strip printer capable of being mounted directly in the main MFAC enclosure. Alarms are to be printed in easy-to-read RED, other messages, such as a trouble, are to be printed in BLACK. This printer is to receive power from the system power supply and shall operate via battery back up if AC mains are lost.

C. The printer is to provide hard-copy printout of all changes in status of the system and shall time-stamp such printouts with the current time-of-day and date. The printer is to be standard carriage with 80-characters per line and is to use standard pin-feed paper. The printer is to be enclosed in a separate cabinet suitable for placement on a desktop or table. The printer shall communicate with the control panel using an interface complying with Electrical Industries Association (EIA) standard EIA-232D.

2.13 WIRE

A. Wires and Cables: to comply with BS 5839 Part 1, section 17.3, and certified to have passed IEC 331 and 332 flame resistance and fire retardant tests. Cables are to be silicone rubber insulated, with overall PVC sheath bonding to coated aluminum foil (FP 200 by Pirelli Cables) or other equal and approved. Conductors are to be copper of minimum size 1.5 mm2 and/or as shown on the Drawings.

B. Conduits and Raceways: to comply with section 16130 of the specification.

PART 3 - EXECUTION

3.1 EQUIPMENT INSTALLATION

A. Connect the MFAC with a disconnect switch with lockable handle or cover.

B. Manual Pull Stations: Mount semi flush in recessed back boxes.

C. Water-Flow Detectors and Valve Supervisory Switches: Connect for each sprinkler valve station required to be supervised.

D. Ceiling-Mounted Smoke Detectors: Not less than 100 mm from a side wall to the near edge. For exposed solid-joist construction, mount detectors on the bottom of joists. On smooth ceilings, install not more than 9 m apart in any direction.

E. Wall-Mounted Smoke Detectors: At least 100 mm, but not more than 300 mm, below the ceiling.

F. Smoke Detectors near Air Registers: Install no closer than 1520 mm.

G. The selection and placement of smoke detectors shall take into account both the performance characteristics of the detector and the areas into which the detectors are to be installed to prevent nuisance alarms or improper operation after installation. Smoke detectors shall not be installed in areas where air velocity is greater than 1.5m/sec, and shall not be located in a direct airflow. If siting of detectors in such areas is unavoidable, use detectors specifically designed for use in such conditions.

H. Duct Smoke Detectors: Comply with manufacturer's written instructions.

1. Verify that each unit is listed for the complete range of air velocity, temperature, and humidity possible when air-handling system is operating.
2. Install sampling tubes so they extend the full width of the duct.

I. Heat Detectors in Elevator Shafts: Coordinate temperature rating and location with sprinkler rating and location.

J. Audible Alarm-Indicating Devices: Install not less than 150 mm below the ceiling. Install bells and horns on flush-mounted back boxes with the device-operating mechanism concealed behind a grille. Combine audible and visible alarms at the same location into a single unit.

K. Visible Alarm-Indicating Devices: Install adjacent to each alarm bell or alarm horn and at least 150 mm below the ceiling.

L. Device Location-Indicating Lights: Locate in public space near the device they monitor.

M. MFAC: Surface mount with tops of cabinets not more than 1800 mm above the finished floor.

3.2 WIRING INSTALLATION

A. Wiring Method: Install wiring in raceway according to Division 16 Section "Raceways and Boxes." Conceal raceway except in unfinished spaces and as indicated.

B. Wiring within Enclosures: Separate power-limited and non-power-limited conductors as recommended by the manufacturer. Install conductors parallel with or at right angles to sides and back of the enclosure. Bundle, lace, and train conductors to terminal points with no excess. Connect conductors that are terminated, spliced, or interrupted in any enclosure associated with the fire alarm system to terminal blocks. Mark each terminal according to the system's wiring diagrams. Make all connections with approved crimp-on terminal spade lugs, pressure-type terminal blocks, or plug connectors.

C. Cable Taps: Use numbered terminal strips in junction, pull and outlet boxes, cabinets, or equipment enclosures where circuit connections are made.

D. Color-Coding: Color-code fire alarm conductors differently from the normal building power wiring. Use one color-code for alarm circuit wiring and a different color-code for supervisory circuits. Color-code audible alarm-indicating circuits differently from alarm-initiating circuits. Use different colors for visible alarm-indicating devices. Paint fire alarm system junction boxes and covers red.

E. Risers: Install at least two vertical cable risers to serve the fire alarm system. Separate risers in close proximity to each other with a minimum one-hour-rated wall, so the loss of one riser does not prevent the receipt or transmission of signal from other floors or zones.

F. Wiring to Remote Alarm Transmitting Device: 25-mm conduit between the MFAC and the transmitter. Install number of conductors and electrical supervision for connecting wiring as needed to suit monitoring function.

3.3 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals according to Division 100 Section "Basic Electrical Materials and Methods."

B. Install instructions frame in a location visible from the MFAC.

C. Paint power-supply disconnect switch red and label "FIRE ALARM."

3.4 GROUNDING

A. Ground cable shields and equipment according to system manufacturer's written instructions to eliminate shock hazard and to minimize, to the greatest extent possible, ground loops, common-mode returns, noise pickup, cross talk, and other impairments.

B. Signal Ground Terminal: Locate at main equipment rack or cabinet. Isolate from power system and equipment grounding.

C. Install grounding electrodes of type, size, location, and quantity as indicated. Comply with installation requirements in Division 100 Section "Grounding and Bonding."

D. Ground equipment and conductor and cable shields. For audio circuits, minimize, to the greatest extent possible, ground loops, common-mode returns, noise pickup, cross talk, and other impairments. Provide 5-ohm ground at main equipment location. Measure, record, and report ground resistance.

E. Ground radio alarm transmitter system and equipment as recommended by the manufacturer.

3.5 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components and connections and to supervise pre-testing, testing, and adjustment of the system. Report results in writing.

B. Pre-testing: After installation, align, adjust, and balance the system and perform complete pre-testing. Determine, through pre-testing, the compliance of the system with requirements of Drawings and Specifications. Correct deficiencies observed in pre-testing. Replace malfunctioning or damaged items with new ones, and retest until satisfactory performance and conditions are achieved. Prepare forms for systematic recording of acceptance test results.

C. Report of Pre-testing: After pre-testing is complete, provide a letter certifying the installation is complete and fully operable, including the names and titles of witnesses to preliminary tests.

D. Final Test Notice: Provide a minimum of 10 days' notice in writing when the system is ready for final acceptance testing.

E. Minimum System Tests: Test the system according to procedures outlined in NFPA 72. Minimum required tests are as follows:

1. Verify the absence of unwanted voltages between circuit conductors and ground.
2. Test all conductors for short circuits using an insulation-testing device.
3. With each circuit pair, short circuit at the far end of the circuit and measure the circuit resistance with an ohmmeter. Record the circuit resistance of each circuit on record (as-built) drawings.
4. Verify that the control unit is in the normal condition as detailed in the manufacturer's operation and maintenance manual.
5. Test initiating and indicating circuits for proper signal transmission under open circuit conditions. One connection each should be opened at not less than 10 percent of initiating and indicating devices. Observe proper signal transmission according to class of wiring used.
6. Test each initiating and indicating device for alarm operation and proper response at the control unit. Test smoke detectors with actual products of combustion.
7. Test the system for all specified functions according to the approved operation and maintenance manual. Systematically initiate specified functional performance items at each station, including making all possible alarm and monitoring initiations and using all communications options. For each item, observe related performance at all devices required to be affected by the item under all system sequences. Observe indicating lights, displays, signal tones, and annunciator indications. Observe all voice audio for routing, clarity, and quality, freedom from noise and distortion, and proper volume level.
8. Test Both Primary and Secondary Power: Verify by test that the secondary power system is capable of operating the system for the period and in the manner specified.

F. Re-testing: Correct deficiencies indicated by tests and completely retest work affected by such deficiencies. Verify by the system test that the total system meets specified requirements and complies with applicable standards.

G. Report of Tests and Inspections: Provide a written record of inspections, tests, and detailed test results in the form of a test log. Submit log on the satisfactory completion of tests.

H. Tag all equipment, stations, and other components at which tests have been satisfactorily completed.

3.6 CLEANING AND ADJUSTING

A. Cleaning: Remove paint splatters and other spots, dirt, and debris. Touch up scratches and marred finish to match original finish. Clean unit internally using methods and materials recommended by manufacturer.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Employer's maintenance personnel on procedures and schedules for operating, adjusting, troubleshooting, and servicing system.

1. Provide a minimum of eight hours' training in operation and maintenance.

3.8 ON-SITE ASSISTANCE

A. Occupancy Adjustments: When requested within one year of date of Substantial Completion, provide on-site assistance in adjusting sound levels, controls, and sensitivities to suit actual occupied conditions. Provide up to three requested visits to Project site for this purpose.

END OF SECTION 10012

SECTION 10013 - TELEPHONE SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Conditions of Contract and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Scope of Work: Complete telephone system including, but not limited to, the following:

1. Electronic private automatic branch exchange (EPABX).
2. EPABX peripheral equipment.
3. Operator's console.
4. Telephone sets.
5. Power supply equipment.

6. Ancillary equipment.
7. Telephone distribution networks (for internal telephone lines and trunk telephone lines)

B. Requirements of the following Sections apply to this section:

1. Division 100 Section "Basic Electrical Materials and Methods".
2. Division 100 Section "Conductors and Cables".

1.3 DEFINITIONS

A. (E)PABX: (Electronic) Private Automatic Branch Exchange.

B. MDF: Main Distribution Frame.

C. MTC: Main Terminal Cabinet .

D. DF-E: Distribution Frame (internal telephone).

E. DF-T: Distribution Frame (trunk telephones).

F. DBT – Distribution box (trunk telephones)

G. DB-E – Distribution box (internal telephones)

1.4 SUBMITTALS

A. Product Data: For each type of product indicated including complete technical data and manufacturers catalogues for all equipment and materials.

B. Factory Tests: EPABX and related equipment are to be tested at manufacturer's premises, and test certificates, certified by an official testing authority, are to be submitted to the Engineer before shipping and delivery to site.

C. Shop Drawings: Include dimensioned plans and elevation views of components. Show access and workspace requirements. Include at least the following:

1. Detailed system schematic diagram
2. Exact routing and layout of all cabling and wireways
3. Exact composition of EPABX cabinet(s), terminal boxes and other distribution boxes
4. Typical installation details of cabinet(s), boxes, and other equipment.
5. Detailed floor layouts showing all outlets with label reference and exact routing of cabling and wireways.
6. Detailed system schematic diagram. Differentiate between manufacturer-installed and field-installed wiring. Include diagrams for equipment and for system with all terminals and interconnections identified.
7. Detailed equipment layout in rooms & closets including elevations and typical installation details.
8. Battery: Sizing calculations.
9. System Operation Description: Detailed description for this Project, including method of operation.

D. Operating Instructions: For mounting at the EPABX room.

E. Product Certificates: Signed by manufacturers of system components certifying that products furnished comply with requirements.

F. Installer Certificates: Signed by manufacturer certifying that installers comply with requirements.

G. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.

H. Maintenance Data: Include in maintenance manuals specified in Division 1.

I. Submissions to Authorities having Jurisdiction: In addition to distribution requirements for Submittals specified in Division 1 Section "Submittal Procedures" make an identical submission to authorities having jurisdiction. Include copies of annotated Contract Drawings as needed to depict component locations to facilitate review. Resubmit if required to make clarifications or revisions to obtain approval. On receipt of comments from authorities having jurisdiction, submit them to Engineer for review.

1.5 QUALITY ASSURANCE

A. Manufacturer Qualifications: A firm experienced in manufacturing systems similar to those indicated for this Project and with a record of successful in-service performance.

B. Compliance with Local Requirements: Comply with applicable building code, local ordinances and regulations, and requirements of authorities having jurisdiction.

C. Codes and Standards: Telephone installations are to comply with the requirements of NFPA and the relevant CCITT recommendations.

1.6 WARRANTY

A. Guarantee and Warranty: Supervise and take responsibility for the operation of the system during the experimental period. After the satisfactory completion of this period, the system shall be taken over by the Employer, as per contract conditions, whereby a two-year guarantee period shall commence. This Maintenance Guarantee and warranty will not relieve the Contractor of his responsibilities under the contract (General Conditions of Contract).

1.7 EXTRA MATERIALS

A. All spare parts, which might be needed to replace existing components during the guarantee period, shall be provided unless the component to be replaced was defected by abuse by Employer's employees.

B. Equipment Keys: Three copies of each kind of equipment key, whatsoever, shall be handed over to the Employer on the date of Substantial Completion.

C. Directory: Make the directory according to the approved numbering plan. To hand over, on the date of substantial completion, sufficient copies of the directory, which shall be printed in a sheet form, covered on both sides by transparent plastic protection, or in pocket-book form, properly bound, or mixture of both, subject to the agreement with the Engineer.

D. Spare Parts: Supply of a set of spare parts for the Employer's convenience after guarantee period. This set shall include minimum items to fulfill two years operation requirements such as electronic boards as recommended by manufacture (including extension boards).

E. Tools: Supply maintenance tools. These tools are to include all items relevant to the first-level maintenance, such as:

1. Electronic-board extractors, power-converter extractors, and cleaning kit (as needed according to the type of EPABX.
2. EPABX-test station (as recommended by manufacture)
3. Digital multi-meters.
4. Wiring and testing kit (including IDC tools, test plugs, disconnecting plugs, etc.)
5. Complete mechanical kit.
6. Battery service kit, if batteries are not perfectly sealed (including density meter, level meter, etc.)

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Approved Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

1.	Alcatel	(France)
2.	AT & T	(USA)
3.	British Telecom	(U.K.)
4.	Ericson	(Sweden)
5.	I.T.T.	(U.S.A.)
6.	Mitel	(U.K.)
7.	N.E.C.	(Japan)
8.	Northern Telecom	(Canada)
9.	Philips	(Holland)
10.	Siemens	(Germany)
11.	Thomson-CSF	(France)

2.2 ELECTRONIC PRIVATE AUTOMATIC BRANCH EXCHANGE SYSTEM (PABX)

A. Type: EPABX is to be compatible with the relevant public exchange equipment. The EPABX is to be a wholly electronic exchange, fully digital, stored program controlled. System is to be an integrated voice/data, which is capable of transmitting voice and data simultaneously over a standard two-wire telephone line. Nevertheless, EPABX is to be designed for use as a standard telephonic exchange for all applications. It is to be possible to connect any combination of standard serial-pulse and DTMF telephones to the EPABX, with manufacturer-made interface modules as necessary within the exchange and without the need to modify the assembly. The exchange is to be capable of supporting applications requiring ISDN (Integrated Service Digital Network), 557, CTI and latest for exchanges.

B. Cabinet(s): Exchange components are to be grouped in a modular, totally enclosed, sheet metal cabinet, corrosion resistant, with lockable front access doors, and the whole assembly is to fit into one integrated form. Cabinet(s) is to be dust and insect proof, and ventilation is to be provided as required for specified ambient conditions as well as air-conditioning facilities.

C. Plug-in Equipment: Electronic circuits and components, which are all solid state components, are to be plug-in card type. Equipment is to be assembled neatly in racks. Sensitive components are to have dust protection covers.

D. Operator Console(s): Comprise two units, properly assembled together; a multifunction keyboard unit, and an alphanumeric display unit. The console(s) are to be compact and to have an ergonomic design. The display unit can be adjusted to various angles to facilitate adaptation to different viewing distances, eye levels, and lighting. The console(s) are to be flush fitted in a manufacturer-approved desk(s) which are specially designed for the purpose and

included in the present scope of work. They may also be desktop console(s), with relevant stand(s). The console(s) are connected to the exchange cabinet(s) by relevant cabling and does not require any external power connections.

E. Diagnostic Capability: EPABX is to be self-diagnostic to indicate and analyze the fault to enable identification of the source of trouble. Exchange is to have remote diagnostic capability so the manufacturer's technical assistance center can access the system over a dial-up port.

F. Man-machine dialogue is to be ensured by terminal unit(s). Each unit is to be composed of a keyboard associated with a printer and/or a video display terminal. It is be possible to monitor, manage, and dialogue with the system at any time. These units are to be protected against misuse by means of a selectable password. The units are to be supplied with suitable stands including a relevant compartment for EPABX documentation and drawings.

G. EPABX is to be provided with a PC station for monitoring and control of the EPABX functions, located near the EPABX. The PC station is to provide at least the following functions:

1. Storing of outdoor telephone calls, including telephone number, country called, extension called from, duration period etc.
2. Management of the exchange with the possibility to have all the facilities listed in clause "herein", and for the VDU operator console.
3. Storing for Errors occurring on the system.
4. Database giving cost details for telephone and fax calls dialed from the exchange.
5. Data to be capable of being stored on the PC hard disk without being backed up at least one month.
6. Computer to be state of the art with double CPU and hard disk capacity for storing of all data stated above, CD-ROM drive, Network card, floppy drive, 17" monitor.

H. Data Memory Floppy Disk Drives: EPABX is to contain floppy disk drives, and a relevant stock of floppy disks are to be supplied as recommended by the manufacturer. Floppy disks are to be used for storage of all system and user data, to serve as back-up storage for protection of system configuration data and operating system software.

I. Exchange Capacity: Equipment is to be designed for two distinct capacities; a present capacity, for which the exchange is to be wired and equipped with electronic cards; and an ultimate cabinet(s) - capacity, for which the exchange may be wired merely. It is to be possible to simply expand the exchange to its ultimate value by plugging in extra electronic cards within the same initial cabinet(s). Capacity is to be as follows:

1. External Trunk Lines: [64] lines, expandable to an ultimate capacity of [72] lines.
2. Internal Extensions: [640] lines, with ultimate capacity of [720] lines.
3. Operator's Console(s): [1] with provision for expansion to [3] consoles.

J. Technical Data: EPABX is to be in accordance with CCITT recommendations and is to meet, at least, the following specifications:

1. Minimum Traffic Capacity: 0.22 erlang/extension.
2. Technology: Modular structure, digital switching, voice/data traffic, stored program control with TTL and MOS VLSI and/or LSI integrated circuits.
3. Insertion Loss: Less than 0.6 dB at 800 Hz, less than 1.5 dB at 300-3400 Hz.
4. Cross-talk Attenuation: More than 70 dB 300Hz, 0 dBm.
5. Maximum Resistance of Extension Line Circuit: 1500 ohms (including telephone set)
6. Digital Line Circuit: 144 kb/s full duplex (2B+D), synchronous up to 64 kb/s, asynchronous up to 19.2 kb/s
7. Compatible Telephone Stations: As per articles about telephone sets hereafter.
8. Access to external networks: Tie-line terminals to other EPABX's. PCM-link terminals for distributed structures. ISDN compatible.
9. Primary Power Supply: 220 Volts (+1-15%)a.c., single phase; 50 Hz.
10. Battery Voltage Supply: 48 Volts d.c. Nominal (+1-12%).

K. Numbering design is to permit station number to be assigned to lines at time of installation, in accordance while customer-desired numbering plan, and reassignment while in service to allow personnel moves without requiring number changes.

L. Classes of Service: The EPABX is to have different operational features; each feature shall be attributed to all or part of the stations which shall be classified and grouped thereby into different classes according to their communication requirements. This system shall inherently impose certain external-call restrictions so as stations are to be classified to authorized stations and non-authorized ones. Authorized stations shall also be classified according to their ability to access external trunk lines directly, or via operator(s), and according to their ability to make international calls. The Contractor is to submit, for the approval of the Engineer, a detailed description of the various classes of service proposed for the system. Nevertheless, all classes are to be flexible and software controlled so as the client can easily modify them should it deem needed in future.

M. Segregation of External Trunk Lines: It must be possible to segregate incoming trunk lines so as to make some of them accessible only by operators and some others accessible by operators and authorized stations.

N. Trunk-lines management facilities are to be included to have a complete call information logging. It is to be possible to store and print upon request the full list of outward calls, with indication of number called, number of internal station originating the call, date, time and duration of call.

O. Data Transmission Capabilities: EPABX internal network structure is to offer user access to data transmission facilities at all points where normal 2-wire telephone capabilities exists. The primary means of connecting workstations, terminals, terminal systems and computer equipment to the system, when needed, shall be via terminal adapter units (the supply of these units is not included in the present scope of work). The system shall permit computer and modem resource sharing, shall support synchronous transmission speeds up to 64 kb/s and asynchronous transmission speeds up to 19.2 kb/s.

P. PC/LAN Connections: The PABX internal network is to allow IBM compatible PC's to intercommunicate in a multi-net LAN environment, thus permitting file and device sharing if needed.

Q. EPABX Features: Include, but not limited to the following:

1. Dial Access to Operator: Station users are to be able to reach operator by dialing a single digit, and operator may complete these calls to trunk facilities or other stations.
2. Internal Calls: Station user is to be able to directly dial other stations within the system without assistance of operator.
3. Direct Outward Dialing: Authorized station users are to be able to access public network, without assistance of operator, by dialing a one-digit access code, receiving a public dial tone, and then dialing desired external number.
4. Call Transfer: Enables any station in the system to directly divert a call to another station or the operator.
5. Camp on Busy Station (Automatic call back on busy): If station A is calling station B, who is busy, it is to be possible for a to dial a camping code and hang up; the two stations are automatically called back as soon as they are simultaneously free.
6. Camp on Free Station (Automatic call back on no reply): If station A is calling station B, who is temporary absent, it is possible for a to dial the camping code and hang up; the two stations are automatically called back as soon as b uses his set and hangs up while a is still free.
7. Inquiry Call: When telephone user is in conversation with the outside, he is to be able to put his communication on hold, dial an internal number, consult privately, and then resume the first communication.
8. Parking (Call Park): Parking a call means to make it wait in order to hang up and resume it thereafter, either from the same station or from any other station.
9. Three Party Conference: Enables a station, having an established call to include a third party and create a conference session.

10. Call Forwarding (call diversion): Required to allow a station user to have his incoming calls diverted to a common answering position or to a predetermined set.
11. Follow Me: Required to enable any station to temporarily move incoming calls to another station position.
12. Call Interception (call pick-up): Required to enable a member of a defined group of stations to pick-up a call addressed to another member.
13. Secretary Filter: Required to enable certain stations to receive calls intended for one or several managers, and transfer these calls to them.
14. Priority break-in (third party entry, or executive override): A station user, if so allowed by his class, is to be able to enter existing two-party connection should he dial the number of one of these two parties and find him busy; this intrusion is to be preceded by a warning tone; if the person called releases his line, he is automatically called back.
15. Public-network Number Storage: Required to enable authorized stations, to store and redial a public telephone number.
16. External Abbreviated Dialing: Required to enable operator(s) and authorized stations to make external calls by dialing an abbreviated code which is automatically converted to a full number and sent out by the exchange.
17. Call-back Queuing for Trunks: Allows the user to wait for a trunk to be idle; when the trunk is idle, the exchange rings back, then the user may go off-hook and dial the desired number.
18. Direct Inward Dialing (DID): Required, subject to arrangements with the local telecommunication authority, for incoming external calls to be addressed to internal stations directly without the operator's intervention.
19. Call Waiting Indication: Required to enable a station to receive/send an audible tone indicating that an internal or external call is waiting.
20. Line Lockout with Warning: Gives 5 seconds warning tone and then holds the line out of service after a station line remains off-hook for longer than 10 seconds without dialing; the hold out-of service is to be released when station goes on-hook.
21. Trunk Line through Connection: Automatic connection of [20] trunk lines to some predetermined extensions in the event of power failure or processor malfunction.
22. It shall be possible for an external caller to listen to a pre-recorded menu inviting him to address extension dialing, voice messaging, the operator ... Etc., Subject to further dialing code.

R. Operator's console(s) general features are to include at least the following:

1. Transfer of Incoming Call: Operator(s) is to be able to connect any internal station or outside trunk line with any other internal station; operator(s) is to be able to place an outgoing call for a station user without requiring the station user to hang up.
2. Calling Number Display: Visual display of the station seeking attendant service or the station dialed by the operator(s).
3. Serial Call: Operator(s) is to be able to complete an incoming trunk call to two or more station lines in succession without requiring the outside party to recall operator.
4. Camp on Busy: It shall be possible for the operator(s) to camp a call on to a busy station.
5. Call Hold: Calls that cannot immediately be extended, may be placed in a hold buffer; when required station become available, the call is to be retrieved from hold buffer and extended to the station.
6. Automatic return to operator if an extension does not answer an outside call within 20 seconds.
7. Priority Break-in (operator intrusion): Operator is to be able to interfere in an established communication for special announcements or transfer of incoming calls; warning tone is to be sent to both conversing parties.
8. Call Splitting: Operator is to be able to consult privately with one party of an existing call without the other party being able to here the consultation.
9. Time Reminders: Operator is to be automatically alerted after 30 seconds when an internal or outside call on the console is waiting.
10. Automatic and Manual Switch-over to Night Service: Incoming trunk calls during night operation are to be routed to predetermined answering stations; routings are to be on a flexible basis and are to remain in effect until changed.

2.3 STANDARD TELEPHONE SETS

A. Set Type: Desk-type or wall-type as shown on drawings. Dial is to be via push-button standard serial-pulse and DTMF, switchable. The telephone user is to have access to all system features, subject to classes of service as assigned individually to each station.

B. Set Description: Set is to be shock-resistant molded plastic, of approved design and color, and appropriate for the function intended. Sets are to be dust and insect proof with bell and adjustable volume control. Set is to have lock-in jack ended connector cord, not less than 2.5 m long, for connecting the base to wall-outlet, and a spiral connector cord between the handset and the base. Jacks are to snap-lock into corresponding mates, and may be released easily without special tools.

C. Set Characteristics: Push-button telephone pad with redial and mute buttons. Capsules are to be sensitive, highly reliable, light weighted and rugged. The set is to show a uniform frequency response and an optimum impedance adaptation to the extension lines in the whole band from 300 to 3400 Hz. Both the receiver and the microphone shall have an insulation resistance that is not less than 10 Mega-ohms at 250 V (dc) between the two terminals (linked) and the metal body.

2.4 MAIN TERMINAL CABINET (MTC)

A. Location and Objective: terminal cabinet is to be located in lower ground level as shown on the drawings and is to be assigned for the proper interface with public network.

B. Description of Main Terminal Cabinet: the cabinet is to be of high quality metal alloy, to have an approved design and shall to have sufficient space and terminal blocks so as to connect and jumper 2500 public lines. Terminal cabinet is to be equiped with serge protectors for over voltage and over current protection of all connected telephone lines.

2.5 MAIN DISTRIBUTION FRAME (MDF)

A. Description of MDF: the MDF is to be made of high-quality aluminium alloy. It is to be standing, floor mounted, space saving, on-site assembled, flexible design, of modular sections, swing-out feature of compact terminal blocks as necessary, single sided or double sided, transparent covers for connection modules protection, cable ways, wire guide rings, easy break and test access, numbering plates, labelling strips for all terminal blocks, and frame earthing.

B. Size of MDF: the MDF is to be large enough to accommodate the ultimate internal and external capacities of the EPABX, and to wire the full capacities of all riser cables (main cables) plus 20% spare space.

C. Terminal Blocks: each block (head) shall be composed of a set of horizontal connection modules. Connections are to be performed by quick-clip IDC (Insulation Displacement Contact) connectors, no soldering shall be allowed. It is to be possible to directly access front points for inserting test probes. Terminal blocks are to, andbe equiped with provisions shall be available for the insertion of over voltage and overcurrent protection devices as necessaryfor trunk lines connections. There shall be as many connection modules as needed to wire at least the full capacities of all existing cables, including every spare wire.

2.6 DISTRIBUTION FRAMES AND BOXES (DF&DB)

A. Description of Telephone Cabinets (DF, DB): telephone cabinets are to be provided for cables termination and include all distribution frames and distribution boxes. Telephone cabinets are to be of high professional quality, metal alloy, corrosion resistant, wall mounted by screws or freestanding depending on the size, with tamper proof

removable screw covers, cable holder rings, labeling plates, equipped with relevant connecting strips, and have efficient capacities to fully wire the complete incoming cable and outgoing ones plus 20% spare space for further implementation and writing of extra terminal blocks.

2.7 CONNECTION MODULE

A. The terminal blocks in the MDF, NTC, distribution frames/boxes shall consist of IDC (Insulation Displacement Contact) modules They will be of high reliability, and will have the following minimum specifications:

module size	
	10 pairs for MDF and DF
5	pairs for DB
conductor diameter	
	0.4 to 0.8 mm
insulation diameter	
	0.7 to 1.5 mm
number of insertions	
	1000 times
maximum contact resistance	
	0.02 ohm
dielectric strength (50 Hz)	
	2000 V (r.m.s.)
minimum insulation resistance	10000 Mega-ohm, at 500 V (dc)

2.8 TELEPHONE OUTLETS

A. Telephone outlets are to have modular grid box and cover plates similar to other socket outlets and switches described in Section 16143 "Wiring Devices" of the Specification, with approved colour, cord-grip cover, wall mounted with screws. They are to be modular flat-oval telephone-jack plugs with compatible base sockets. Plugs are to have positive locking latches. The connector is not to vibrate loose, and its polarization is to prevent improper insertion. Standard male plugs with compatible mural sockets may also be accepted, subject to the approval of the Engineer.

2.9 POWER SUPPLY EQUIPMENT

A. General Description: The Power supply scheme shall be a low-noise no-break dc power scheme composed of rectifier-charger unit, battery pack, inverters and DC converters as necessary, and power cables. This scheme is to guarantee the continuous supply of d.c power, at the specified rates, to the whole system-load, with at least 25% redundancy.

B. Operation Principle: The rectifier-charger unit shall be used for initial charging and subsequent charge maintenance of the batteries. When the mains supply is present, the unit is fed by the 220 V, 50 Hz and provides the 48 V d.c to the system. Meanwhile, it maintains the batteries fully charged. On failure of the main supply, the batteries automatically take over the supply of power to the load circuit. When the main supply is resumed, the rectifier-charger unit is to automatically re-charge the batteries to its full charge. The rectifier output voltage shall be intrinsically regulated to one of two levels:

1. The floating level, under normal operating conditions where the mains supply is available and the batteries are in stand-by situation.
2. The equalization level (charge level) whereby a higher voltage is provided in order to re-charge the batteries to their full capacity. After the batteries are fully recharged, the rectifier-charger unit is to resume the floating level.

C. Rectifier-charger unit is to be solid state type, lumped or modular, with door and lock. It is to be suitable for the climatic conditions as specified. In addition it is to have sufficient capacity to supply the required power to the PABX and maintain batteries fully charged, with circuit breakers and fuses, voltage and current meters, battery voltage monitoring, earthing connection, high insulation between terminals and earth, protection and alarm indication system.

D. Batteries shall be nickel-cadmium, sealed, maintenance free, floated on load side of rectifier, and kept continuously fully charged. The battery pack shall have autonomy of not less than eight hours. Battery capacity shall provide a minimum of eight hours of continuous telephony-system operation without loss of functions or reduction in performance after mains power supply failure and before the EPABX can be automatically disconnected.

E. Inverters and Converters: Shall be provided as necessary to facilitate the required power to electronic boards and circuits within the EPABX. They shall be modular units, built in the EPABX cabinet(s), approved and supplied by the EPABX manufacturer.

PART 3 - EXECUTION

3.1 INSTALLATIONS

A. General: Equipment installation on site is to be limited to the assembly, layout and fixation, networking, and inter-wiring of various items of the ready made equipment. Acceptance of works shall be restricted to the equipment and installations complying with the approved submittals, approved shop drawings, and the agreement of the Engineer. Proper tools shall be used for all installation works and the contractor shall carry out these works under the direct supervision of qualified technicians who are well trained and having the relevant experience.

B. Co-ordination with Other Works: Undertake the proper co-ordination between the installations of the telephony system and those of all other systems. The layout shop-drawings shall reveal the measures taken therein, and every fixation principle, and detail, shall be subject to the approval of Engineer.

C. Layout and Fixations of Equipment: Cubicles and cabinets shall be laid out properly so as to ensure the optimum utilization of room areas and to reserve relevant spaces for maintenance activities as well as future extensions of the system. The availability of adequate lighting levels must also be ensured for all cubicles and cabinets; should it deem difficult to fulfil this condition at some location, a mains outlet shall be provided nearby (less than 0.5m apart) so as special lighting can be provided during maintenance. Fixations shall be as appropriate; above metallic chassis at the level of false floor for bottom-sided cabling, above floor for top-sided cabling, on wall for wall mounted units, under false floor or above false ceilings where preferable for small distribution boxes. Batteries shall be mounted in the well-ventilated battery room where suitable mounting rack is to be provided in the appropriate location. Operator console(s) shall be oriented in accordance with approved drawings, fulfilling optimum operation conditions, and the display unit shall not be subject to direct sun light through any windows thereat. After the layout

of equipment is accomplished, all sorts of cubicles, cabinets, and system components shall be labeled, and marked properly according to an approved labeling designations and materials.

D. Raceways telephone cables shall run in dedicated raceways apart from those where power cables are laid. Moreover, telephone cables shall not share undivided trays or paths with any other type of cables.

E. Jumper wires are to extend neatly between connection modules, moderately stretched, and guided by the specialized rings and hooks. No jumper shall be left loose or imperfectly guided. The final arrangement of jumper wires within any cubicle shall allow for an easy trace of any telephone line.

F. Earthing: Properly earth all equipment. Earthing system shall ensure safety conditions and shall eliminate the relevant noise effects. Earthing cables shall be characterized by their green/yellow color.

3.2 ON-SITE TESTS, AND INSPECTION:

A. Tests Plans: All tests shall be carried on according to detailed test procedures which were submitted and approved by Engineer. The tests shall cover every aspect related to the specification of the material and their operation; including, but not limited to, visual inspections, insulation tests, measurements, and operation. All instruments to be used during the tests must have been calibrated and certified, by an authorized official laboratory, as complying with the specification of their manufacturers.

B. On-Site System Tests: Equipment shall be tested to ensure that they are not damaged by transportation, correctly assembled and connected, properly powered, and operating as specified. The complete system tests shall include the following minimum checks:

1. Visual inspection of every component
2. Dielectric strength and insulation resistances.
3. EPABX voltages and currents.
4. System performance (including all operation features)
5. Any other checks as necessary to ensure full compliance with the technical specifications.

C. It is to be demonstrated, to the satisfaction of Engineer, that the installed equipment meets the requirements of the specification and is ready for taking-over.

D. Experimental Period: After the on-site tests are satisfactorily completed in accordance with the technical specifications and approved procedures, and before Substantial Completion, assume a one-month experimental period during which the system performance shall by fully demonstrated under actual operation conditions. This demonstration is to confirm, to the satisfaction of the Engineer, that the system is ready for taking over.

3.3 DEMONSTRATION AND TRAINING

A. Train Employer's maintenance personnel to adjust, operate, and maintain the system installation.

END OF SECTION 10013

SECTION 10014 - MEDIUM-VOLTAGE SWITCHGEAR

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Conditions of Contract and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes medium-voltage switchgear and associated auxiliary equipment.

B. Description Of Work: medium voltage (MV) switchgear installations comprise the following:

1. Indoor meteal enclosed ring main units.RMU
2. Equipment supports.
3. Earthing of switchgear.
4. Ancillary work.

C. Related Sections include the following:

1. Division 100 Section "Basic Electrical Materials and Methods".
2. Division 100 Section "Grounding and Bonding".
3. Division 100 Section "Medium-Voltage Cables" for cable terminations at switchgear.

1.3 SUBMITTALS

A. Product Data: Submit full technical data of equipment for approval including, but not limited to, the following:

1. Manufacturers' catalogues, detailed description of construction, provisions for extension, compliance with the Standards, dimensions and weights, operating characteristics, operating curves and error curves (VT, CT) for all switchgear, control gear, protective gear, metering gear etc.
2. Details of miscellaneous items including pilot lights, cabling or wiring, incoming and outgoing feeder terminal fittings, supports, labels, interlocks, bracing etc.

B. Shop and Construction Drawings: Submit drawings for approval including, but not limited to, the following:

1. Plans and elevations, with indication of switchgear mounted components, dimensions and weights.
2. Arrangement of equipment and general layouts.
3. One-line diagram of power system showing current ratings of switchgear and busbars and types and locations of protective gear (relays, metering instruments, CTs, VTs) etc.
4. Schematic and elementary diagrams of control circuits.
5. Foundation details, grouting holes and installation details.

6. Physical arrangement of incoming and outgoing feeders, instrument transformers, busbars, connections etc.
7. Dimensions and weights of control power supply and other auxiliary equipment or components.

C. Technical Literature: Submit the following for approval prior to equipment manufacture:

1. Schedule of selected circuit breakers, relays and control gear, with complete identification of each component and its characteristics.
2. Protection coordination scheme, including pick-up settings and time-grading, together with time-current curves and range of adjustments etc. as required to coordinate with upstream and downstream protective devices of the complete system.

D. Type Test Certificates: Submit to verify compliance of main equipment with the relevant IEC Standards, including the following:

1. Impulse withstand-voltage tests
2. Power frequency withstand-voltage tests.
3. Temperature-rise tests.
4. Short time current tests.
5. Verification of making and breaking capacity.
6. Mechanical endurance/operation tests.
7. Verification of degrees of protection for persons against contact with live and moving parts.
8. Internal arc tests.
9. Protection degree test to IEC 60529.

E. Routine Tests: Each complete switchgear unit is to undergo routine tests at the manufacturer's works in accordance with the relevant standards. Submit routine test reports, prior to shipping equipment, indicating ambient test conditions and guaranteed rating of equipment under site conditions.

F. Qualification Data: For firms and persons specified in "Quality Assurance" Article.

G. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.

H. Maintenance Data: For switchgear to include in the maintenance manuals specified in Division 1.

1.4 QUALITY ASSURANCE

A. Manufacturer Qualifications: Engage a firm experienced in manufacturing switchgear similar to those indicated for this Project and with a record of successful in-service performance.

B. Standards: Equipment and component parts are to comply with the following Standards:

1. Common Clauses for HV Switchgear and Control Gear Standards: IEC 60694.
2. A.C. Metal-Enclosed Switchgear and Control Gear for Rated Voltages above 1 kV and up to and including 72.5 kV: IEC 60298.
3. HV A.C. Circuit Breakers: IEC 62271.
4. Insulation Coordination: IEC 60071.
5. HV a.c. Fuse-switch combinations and Fuse-Circuit-Breaker Combinations: IEC 60420.
6. A.C. Disconnectors (isolators) and Earthing Switches: IEC 62271.
7. HV Switches: IEC 60265.
8. Surge Arrestors: IEC 60099.
9. Metering and Protective Current Transformers (CTs): IEC 60044-1.
10. Metering and Protective voltage Transformers (VTs): IEC 60186.
11. Relays: IEC 60225.

12. Reading Instruments: IEC 60051.
13. Watt-Hour Meters: IEC 60521.
14. Power Transformers: IEC 60076, 60726.
15. Insulating Oil: IEC 60296.
16. Sulfur Hexa-Fluoride: IEC 60376.
17. Fuses: IEC 60282-1.

1.5 WARRANTY

A. Manufacturer's Warranty: Submit a written warranty signed by the manufacturer agreeing to repair, restore or replace any defective equipment specified in this section during the specified warranty period

1. Warranty Period: 1 year from date of Substantial Completion.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver in shipping splits of lengths that can be moved past obstructions in delivery path as indicated.

B. Store so condensation will not form on or in switchgear.

C. Apply temporary heat where required to obtain suitable service conditions.

D. Handle switchgear using factory-installed lifting provisions.

1.7 PROJECT CONDITIONS

A. Existing Utilities: Do not interrupt utilities serving facilities occupied by Employer or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:

1. Notify Engineer not less than two days in advance of proposed utility interruptions.
2. Do not proceed with utility interruptions without Engineer’s written permission.

1.8 COORDINATION

A. Coordinate layout and installation of switchgear with other construction and room dimensions. Advise the Engineer in case of conflict.

B. Coordinate size and location of concrete or mounting bases. Concrete, reinforcement, and formwork requirements are specified in Division 3 Section "Cast-in-Place Concrete."

C. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 7 Section "Roof Accessories."

1.9 EXTRA MATERIALS

A. Spare Parts: Provide spare parts, as recommended by the manufacturer, for one year maintenance as expected under local conditions, and to allow for emergency replacement due to accidental breakage or failure. Spare parts are to include, but are not limited to, the following:

1. Two sets of each type of lamp, fuse, auxiliary switch, trip coil, control switch, selector switch, neon indicator and the like.

B. Tools and Instruments: Provide tools and instruments required for normal routine inspection, testing, operation and maintenance including levering crank, manual charging handle, manual shutter operator, testing jumpers and HV test bushings, set of rail extensions, digital micro ohm-meter, set of mobile lifting and handling equipment etc. as necessary for the type of switchgear.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Approved Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

1. ABB
2. G.E.
3. G.E.C.
4. Merlin-Gerin
5. Siemens
6. Cuttler Hammer

Country of origin is to be submitted for review/approval.

Complete documentation for the factory manufacturing the equipment is to be submitted including but not limited to, local and international experience, quality certificates, quality assurance plan, and organization .

2.2 GENERAL REQUIREMENTS

A. Busbars: Air-insulated, high conductivity, electrolytic copper, modular, designed to withstand worst short-circuit conditions without allowing permissible temperature rise at ambient conditions to be exceeded, in accordance with the Standards. Busbar connection from one unit of switchgear to another is to be expansion/contraction compensated, plated and bolted. Busbar supports are to be flame-retardant, track-resistant, glass polyester, porcelain or equally reliable fiberglass reinforced epoxy to approved standards.

B. Busbars: Additional epoxy insulation is to be provided to busbars applied by the fluid-dip process. Busbar connections are to be insulated with easily installed, performed vinyl boots, secured by nylon hardware.

C. Earth Bus: Copper of not less than minimum size required by the Standards, designed to withstand worst earth- fault current of power system without showing any signs of thermal or mechanical damage or degradation. Earth bus is to extend full length of switchgear.

D. Power Cable Terminations: Fixed bolted type, unless otherwise specified, complete with standard fittings and accessories for connection of incoming and outgoing cables. Cable compartment is to be designed to permit cables to enter enclosure and connect at respective terminals from below, or as shown on the Drawings. Terminations are to

include appropriate sealing ends, fittings and accessories for type of cable used, including stress cones or other stress relieving accessories, heat shrinkable sleeving, end boxes or end bushings and fittings of any kind necessary to support and protect specified cable ends.

E. Potential Indicators: Neon indicators are to be provided at front of each switchgear unit, one per phase, using capacitive potential divider to indicate voltage state on cable terminals.

F. Interlocks are to be provided on switchgear so that:

1. Circuit breaker cannot be isolated, earthed or put into service position when closed.
2. Access to cable compartments cannot be made unless earthing switch is closed.
3. Earthing switch cannot be opened unless cable compartment is closed.

G. Keys and padlocks are to be provided for manually interlocking two or more units if required. Electrical and mechanical interlocks are to be provided for automatic safe and functional operation of the system as shown on the Drawings/Schedules.

H. Earthing facilities are to be provided for earthing and/or short-circuiting the feeder at its terminals through built-in, safety-interlocked, quick-make earthing switch, without use of loose attachments.

I. Metal cases of instruments and control devices are to be connected by bare copper conductors of not less than 2.5mm2 cross-section to nearest earth bar.

J. Ferrules: Cable and wire ends are to be fitted with numbered ferrules of approved type at each termination. Colour coding is to be as required by the Regulations and the applicable Section of the Specification.

K. Test terminal blocks are to be provided inside insulating covered bases for instruments, instrument transformers, relays etc. in LV compartments.

L. Components are to be interchangeable when of same rating and function.

M. Finish: Inner and outer surfaces of steel enclosures and structure are to be cleaned, phosphatized, primed with rust inhibiting primer and finished with two coats of baked enamel, color standard gray (RAL 7033) unless otherwise approved. Finish is to be vermin and fungus proof and suitable for worst climatic conditions on site.

N. MV Switchgear Ratings:

1. Rated Voltage: 24 kV.
2. Nominal Service Voltage 22 kV.
3. Rated Frequency: 50 Hz.
4. Rated One Minute Power Frequency Withstand Voltage (rms) to Earth and Between Phases: 50 kV.
5. Rated Impulse Withstand-Voltage (1.2/50 micro-sec) (peak): 125 kV.
6. Rated Normal Current of Bus bars: as shown on the Drawings or specified in article "MV Switchgear Assemblies" hereof.
7. Rated Short Time Withstand-Current: 25 kA for 1 seconds.
8. Rated Peak Withstand-Current: 63 kA.

O. Auxiliary Power Supply Rating:

1. Rated Supply Voltage of Closing and Opening Devices and Auxiliary Circuits: 110 d.c. V.

P. Provide at least the following transducers for the medium voltage switchgear :-

Incoming Circuit breakers

- Power factor transducer
- KW transducer
- KWH transducer
- Current transducer (per phase)
- Voltage transducer (per phase)

Outgoing Circuit breakers

- Power factor transducer
- Current transducer (per phase)
- Voltage transducer (per phase)

2.3 INDOOR WITHDRAWABLE METAL-ENCLOSED SWITCHGEAR

A. Type: Single busbar, floor mounted, free standing cubicle type switchgear of modular construction, forming a continuous integral structure extendable at either end, with withdrawable circuit breakers, isolating disconnectors, switch-disconnectors and fuse-switch combinations, as specified or shown on the Drawings.

B. Degree of Protection: IP H6 to IEC 60298 for MV compartments and IP 51 for enclosure, when in the service position.

C. Circuit Breakers: Frame mounted and bolted into position. Frame is to have wheels for handling during installation or maintenance.

D. Busbars: Air-insulated, high conductivity, electrolytic copper, modular, designed to withstand worst short-circuit conditions without allowing permissible temperature rise at ambient conditions to be exceeded, in accordance with the Standards. Busbar connection from one unit of switchgear to another is to be expansion/contraction compensated, plated and bolted. Busbar supports are to be flame-retardant, track-resistant, glass polyester, porcelain or equally reliable fiberglass reinforced epoxy to approved standards.

E. Isolation: Two air-break isolators are to be provided, one on busbar side and one on load side of circuit breaker, interlocked with circuit breaker operation such that isolation or connection of circuit breaker is not possible while circuit breaker is closed. Isolators are to be pad-lockable in the off and earth positions.

F. Compartmentation is to be provided by earthed metallic partitions between switching devices, busbars, cable terminations and LV equipment.

G. Control and monitoring of each unit is to be provided on front panel and is to include mimic diagram, operating handles of main device and earthing switches, position indicators, close and trip push buttons,

potential indicators, identification and instruction plates, protective devices, metering and indicating instruments, key and pad lockable devices, as specified and shown on the Drawings.

H. Access to LV wiring is to be from front of cubicle for control, protection, test terminal blocks and associated LV power connections. Multi-pin, disconnect able, lock-in type plug and socket arrangement is to be provided between circuit breaker and stationary part of cubicle.

I. Anti-condensation heaters with thermostat, switch and pilot lamp and of rating recommended by manufacturer are to be provided in each section of switchgear assembly.

J. Wiring diagram, suitably protected and located inside LV compartment of each unit, is to indicate all data and components related to the particular unit and its external circuitry.

K. Insulating Mat: Anti-slip, synthetic, insulating, rubber mat, minimum 5 mm thick and 900 mm wide, with heavy canvas lining on lower face, is to be provided for full length in front of switchgear assembly.

2.4 RING MAIN UNIT TYPE SWITCHGEAR

A. Type: Indoor metal-enclosed type, factory built and dispatched as a complete assembly.

B. Insulation type:

1. SF6 switching and insulated copper bus bars.

C. Components: Unit is to consist of metal enclosed network ring main switch-disconnectors and outgoing fuse- switch combination(s), as shown on the Drawings, with cable terminal fittings behind dead-front panels, and front- mounted switchgear operation, control, indication and metering devices.

D. Degree of Protection: IP 65 to IEC 60298 and IEC 60529 for MV switchgear and parts and IP 54 for enclosure.

E. Ring Main Switch-Disconnector: General purpose, 3-pole, load-break, short-circuit make, category B to IEC 60265.

F. Switch-Disconnector Rating:

1. Rated Normal Current as shown on drawings.
2. Rated Short-Circuit (peak) Making Current: 63 kA.
3. Rated Short Time Current: 25 kA for 1 sec.
4. Rated Transformer Off-Load Breaking Current: Same as rated short time in previous subparagraph.

G. Switch-disconnector operation is to be by removable handles at front of unit. Switching mechanisms are to be manual, spring charged, quick-make, quick-break, with speed of make and break switching independent of operator. Main switch and earth switch operations are to be separated and safety interlocked with the manual handle inserted in separate access holes to give on/off operation of main switch and earth on/earth off operation of earthing switch. Handle design is to ensure delay between closing and re- opening of main switch or earthing switch, to prevent re- opening of switch immediately. It is to be impossible to move earth switch into or from one position to another inadvertently and only

when main switch is in open position. Indication of switch position is to be mechanical, directly connected to moving contacts. Each switch is to have padlocking device in the closed, open and earth positions.

H. Fuse-Switch Combination: 3-pole, trip-free, of similar construction to switch-disconnector and consisting of load break, short-circuit make fuse-switch combination. Fuse is to be separately located in fuse chamber with interlocked earthing switches providing upstream and downstream earthing of the fuse assembly before allowing access to fuse live terminals. Automatic trip switching is to be by fuse striker pins which actuate common trip-bar in switch mechanism. Once operated, striker pins remain in ejected position, preventing re-closure of switch until fuse has been replaced. Single phasing is not to be possible. Fuses are to be totally enclosed, current limiting, cartridge type, with striker pins withdrawable from front of unit.

I. Accessories are to include the following:

1. 2 N.O. and 2 N.C. auxiliary contacts on each switch.
2. Shunt trip release on fuse-switch combination.
3. Automatic reset earth fault indicator operated by core-balance type CT located near and outside cable terminals and visible from front.
4. Insulating rubber gloves, earthing equipment, fuse tongs, schematic diagram with equivalent ratings and references, operating handle etc. placed inside compartment.

2.5 MV CIRCUIT BREAKERS

A. Type: SF6 circuit breaker using rotating arc or puffer principle, with closed gas circuit, and with pressure detector to prevent operation of circuit breaker in case of loss of gas pressure within the sealed enclosure. Sealed enclosure is to be stainless steel.

B. SF6 breakers, if used, are to be provided with gas filling valve and with pressure switches, one per pole, to initiate alarm in case the pressure of the SF6 gas drops below manufacturer set values.

C. Particulars: In addition to the ratings specified in paragraph 2.2N "MV Switchgear Ratings" of Article 2.2 "General Requirements" hereof, circuit breakers are to have the following ratings:

1. Rated Normal Current: As shown on Drawings or as specified in Paragraph "MV Switchgear Assemblies" hereof.
2. Rated Short-Circuit Breaking Current at Nominal Service Voltage and Percentage D.C. Component in Accordance to IEC 62271: 25 kA.
3. Rated Short-Circuit Making Current (peak): 63 kA.
4. Rated Duty Operating Sequence: 0-3 min - CO-3 min-CO.
5. Rated Transient Recovery Voltage (TRV) for Terminal Faults (peak): 30 kV.
6. Rated Cable Charging Breaking Current: 31.5 A.
7. Rated (single) Capacitor Breaking Current: To be stated by manufacturer (600 A minimum).

D. Operating Mechanism: Mechanically and electrically trip- free, stored energy, spring loaded, manually charged by lever or hand-crank, electrically charged by suitably rated universal motor, and capable of one complete off-on-off cycle in case of loss of control power. Circuit breaker is to have electrical close solenoid and two trip coils, mechanical on and off push buttons, mechanical on/off/charged indicators, operation counter and auxiliary switches to satisfy all functions specified or shown on the Drawings. Five N.C. and five N.O. spare auxiliary switches for future use are to be provided in addition to those required.

Insertion of manual spring charging lever or hand- crank is to automatically disconnect the motor. Slow closing of circuit breaker contacts for inspection and adjustment is to be possible whilst in the disconnected position.

E. Automatic tripping is to be by indirect auxiliary power through CT operated protective relays.

F. Interchangeability: Circuit breakers of different current ratings are not to be interchangeable. Circuit breakers of same current rating are to be wired alike and interchangeable.

2.6 MV DISCONNECTORS (FOR INSTALLATION IN METAL ENCLOSED SWITCHGEAR)

A. Operation is to be by handles at front of unit. Switching mechanism is to be manual, spring charged device, quick-make, quick-break, with speed of switching independent of operator. Disconnector is to have on and off positions, lockable in the off position. Reliable mechanical indicator is to be provided for indicating the two positions.

B. Disconnectors for double busbar system are to be 3- pole, paired, rotary double-break type, mechanically interlocked, separately compartmented, providing positive break indication, as defined in IEC 60129, with contact- position indicating device and reliable method of preventing any earth-leakage currents passing from terminals of one side to terminals of other side of disconnector when in the open position.

C. Ratings are to be compatible with standard circuit ratings and as specified in Paragraph "General Requirements" paragraph 2.2N hereof.

2.7 PROTECTIVE RELAYS, DEVICES AND AUXILIARIES

A. Protective Relays: Solid state, static, sealed type, having high immunity to electric field, with modular design, suitable for operation at 55 deg. C ambient temperature, mounted in dust-tight steel enclosures with cover, with self supervision system test buttons for testing without removing from case, and built in self regulated power supply unit and installed where shown on the Drawings. Adjustments and settings are to be accessible and visible from front of relay.

B. Solid State Relay: Provide with D.C. power from the switchgear power supply, and to be provided with a pilot LED which is to be lit under healthy operating conditions. Relay is to be provided with a self supervision system which upon power supply interruption or a fault condition is to switch off the LED and to initiate an alarm. The rated current and voltage for current & voltage sensing relays are to match that of the corresponding current and voltage transformers of the switchgear respectively. The continuous output rating of the output contacts is not to be less than 10A.

C. Interference and test voltages of the solid state relays are to be as follows:

1. Insulation test voltage, terminal groups between themselves and the relay frame work as per IEC 60255-5: 2 kV, 50 Hz, 1 min.
2. Impulse test voltage, terminal groups between themselves and the relay frame work as per IEC 60255-4: 5 kV, 1.2/50 micro sec.
3. High frequency test voltage, terminal groups between themselves and the relay framework as per IEC 60255-6: 2.5 kV, 1MHZ.

D. Over Current Relay: 3 phase, non-directional, solid state type with two setting stages as follows:

1. Low setting stage for overload protection with current setting range of 50 % to 250 % of rated current and adjustable definite time and inverse time operation modes as per IEC 60255-3.
2. High setting stage (instantaneous) for short circuit protection with current setting range up to 4000% of rated current.

E. Earth fault relay, non-directional, solid state type with two setting stages as follows:

1. Low setting stage of 10 % to 80 % of rated current and adjustable definite time and inverse time operation modes as per IEC 60255-3.
2. High setting stage (instantaneous) with current setting range up to 1000% of rated current.

F. Restricted earth fault relay, on secondaries of distribution transformers having a solidly grounded neutral and rated over 500 kVA, is to be high impedance, instantaneous differential type, current calibrated from 1% - 20% of phase current.

G. Under-Voltage and Over Voltage Relays: Single phase, solid state definite time type with the following setting ranges:

1. Under Voltage Relay: 6 % to 9 % of rated voltage and 0.2 to 6 sec time delay.
2. Over Voltage Relay: 80 % to 9 130 % of rated voltage and 0.2 to 6 sec time delay.

H. Under-Voltage and Phase-Sequence Relays: Under-voltage relay is to be time-delay type, with selectable time/voltage characteristics 0.1 - 1.0 seconds for settings between 60% and 90% of normal voltage, sensed at VT secondaries. Combined under-voltage and phase-sequence relays are to be provided where specified or shown on the Drawings. Phase- sequence relay is to prevent operation (closing) of respective circuit breaker in case of non-conformance of phase rotation.

I. Auxiliary Relay: Suitably rated with sufficient number of N.O. and N.C. contacts for operation in conjunction with protective relays or control/interlocking requirements. Relay is to have two N.O. and two N.C. spare contacts.

J. Control power supply is to be a complete system, including main LV switch, battery charger, batteries, racks and connectors, factory assembled and completely pre-wired to minimize field installation.

K. Auxiliary LV power is to be obtained from a self contained control power transformer unit supplied with the switchgear, when specified or shown on the Drawings. Where two alternate sources of LV power are shown/specified, an automatic transfer switch with manual over-ride and off- position is to be provided.

L. Batteries: Nickel cadmium type, of capacity sufficient to supply all MV switchgear auxiliary loads, relays, coils, lamps, alarms etc. for 8 hours, to close all circuit breakers in rapid succession, and trip all circuit breakers simultaneously with the charger off. Battery is to be heavy-duty type with transparent containers, maximum and minimum electrolyte level indicators and alarm initiating relay in case of D.C. output failure.

M. Battery Racks: Generously dimensioned termite resistant hardware with electrolyte resistant paint finish, or square sectioned steel tubes treated with electrolyte resistant extruded coating. Fittings and connectors are to be approved and certified electrolyte resisting and corrosion proof materials.

N. Battery Charger: Automatic voltage controlled, solid state type, suitable for float and boost charging, returning batteries to 90% full charge within 4 hours after full discharge, plus full duty cycle required of batteries. Charger is to operate from 110 V supply 60 Hz, single- phase, giving specified D.C. output and having minimum range of adjustment of 100% - 125% float voltage and 110% - 135% boost voltage. Ripple is not to exceed 1% of nominal output voltage. Charger is to be rated 125% of its nominal full load and is to have its own automatic control against overcharging and overload protection. Charger is to have a.c. voltmeter, D.C. voltmeter, D.C. ammeter, main incoming circuit breaker, pilot lights on a.c. input and D.C. output, and earth fault detector with alarm indication.

O. Battery Charger Type: Is to be Single charger type.

2.8 METERING INSTRUMENTS - INSTRUMENT TRANSFORMERS

A. Instruments Generally: Housed in enameled, square steel cases for switchboard flush installation, size 96 x 96 mm with 5 mm frontal, protected and sealed white background dials with black pointers (in general) and anti- parallax shadow-proof glass covers. Accuracy of instruments is to be class 1.5 unless otherwise specified. Moving parts are to be damped, revolving on hard-stone bases, with zero adjustment screw.

B. A.C. Voltmeters: Moving iron type, operating from VT secondary's, and with the following characteristics:

1. Measuring Range: 1.25 x system nominal voltage in kV kV with red line marked on nominal voltage, 250 degrees decimal scale.
2. Overload Factor: 1.2 times rated voltage continuous and twice rated voltage for 1 minute.

C. D.C. Voltmeters: Moving coil type, with the following characteristics:

1. Measuring Range: 1.25 x d.c. aux. power voltage V.
2. Overload Factor: 1.2 times rated voltage continuous and twice rated voltage for 1 minute.

D. Voltmeter Selector Switch: 7-position, rotary type, with cam-operated contacts, permitting line-to-line and line- to-neutral voltage readings, and with off position.

E. Ammeters: Moving iron type, operating from CT secondary, and with the following characteristics:

1. Measuring Range :1.25 CT primary amps, 250 degrees decimal scale
2. Overload Capacity: 1.2 times measuring range continuous, twice measuring range for 2 minutes, and fifty times measuring range for 1 second.

F. D.C. Ammeters: Moving coil type, with the following characteristics:

1. Measuring Range: 2 x normal d.c. range A.
2. Overload Capacity: Ten times measuring range for 5 seconds.

G. Power Factor Meters: Totally enclosed, 3-phase, electro- dynamic type, with cross-coil meter movement and accuracy of 1% from at least 20% - 100% rated current at rated voltage.

1. Measuring Range: 0.1 conductive-unity-0.1 capacitive

H. Wattmeter's: Totally enclosed, 3-phase, electro-dynamic type, with overload factor of 1.2 times continuous.

1. Measuring Range: 1.25 * Rated kW:

I. Watt-Hour Meters: 3-phase, to IEC 60521, unless otherwise required by the Local Power Authority, for operation from 5 A CT secondaries.

J. Frequency Meters: Vibration (reed) type, rated frequency 60 Hz, class 1, rated frequency range 45-55 Hz, and unaffected by voltage variations of +/-20%.

K. Current Transformers (CTs): Indoor dry type (cast- resin), with the following characteristics:

1. Metering (general): Class 1, 5 A secondary.
2. Protection: 5 A secondary.
3. Kilowatt-Hour-Metering: Class 0.5, [5][1] A secondary (check with power authority).

L. Rated primary current, core size and accuracy limit factors are to be determined in accordance with nominal current of plant protected, short-circuit level and burden. CT is to perform under specified conditions without exceeding accuracy limit. Submit error curves for approval. Thermal short-circuit rating is to be 100 times rated primary current with dynamic short-circuit rating of 2.5 times thermal rating.

M. Voltage Transformers (VTs): Magnetic, single-phase, indoor, dry type (cast-resin), with the following characteristics:

1. Rated Voltage:
   a. Primary: (11-13.8) / $\sqrt{3}$ kV.
   b. Secondary: 110/ $\sqrt{3}$ V.
2. Accuracy Class: 0.5.
3. Rated Voltage Factor: 1.2 continuous, 1.9 for 30 seconds.

N. Check associated burden and ensure VT can perform satisfactorily under specified conditions. Submit error curves for approval.

2.9 MICROPROCESSOR BASED METERING AND MONITORING UNIT

A. General: A microprocessor based metering unit is to be provided on the incoming and/or outgoing feeder panels of the MV switchgear as specified and/or as shown on the drawings. Unit is to be capable of monitoring and displaying the functions listed below as well as providing the protection function indicated and the capability to munication data. Unit is to be similar to Cutler Hammer type IQ DP-4000 or other equal and approved.

B. Direct reading metered values are to be displayed by the unit as follows:

1. AC amperes in each phase, +/-0.5% accuracy
2. AC voltage, phase to phase, phase to neutral, +/-0.5% accuracy

3. Megawatts, +/-1% accuracy
4. Megavars, +/-1% accuracy
5. Megavoltamperes, +/-1% accuracy
6. Power factor, +/-2% accuracy
7. Frequency, +/-0.1 Hz accuracy
8. Megawatt demand (5,10,15,30 minute interval field programmable), +/-1% accuracy
9. Megawatt , megavars and VA hours, +/-1% accuracy
10. %THD , +/- 1%

C. Trip and/or Alarm: Device is to trip and/or alarm on the following conditions as shown on the drawings.

1. Voltage phase loss, if any phase RMS is less than 50% of the nominal line voltage.
2. Current phase loss, if the smallest phase is less than 1/16 of the largest phase value.
3. Line voltage phase unbalance, programmable from 5 to 40% of nominal in 5% increments.
4. Voltage phase reversal
5. Over-voltage, programmable from 105 to 140% in 5% increments
6. Under-voltage, programmable from 95 to 60% in 5% increments

D. Device is to have a time delay for the trip and/or alarm settings for over-voltage, under-voltage and phase unbalance. Delay is to range from 0 to 8 seconds in 1-second intervals.

E. Display screen and LEDs are to indicate both trip and alarm conditions. Cause of a trip or alarm is to be indicated on the display window. Device is also to signify reverse power flow, negative power factor and negative kVAR. Unit is to trip in the event of an internal malfunction.

F. Control power is to be drawn from the monitored incoming AC line terminal connections. Device is to have non-volatile memory and not require battery backup. In the event of a power failure, the device is to retain preset parameters.

G. Unit is to allow user to disable undesired values or functions and to later reactivate them if required. In the event of trip or alarm condition, a built-in reset button is to allow a manual reset of the unit. Unit is also to be capable of being remotely reset via its communication port.

H. Addressable communication card is to be provided, capable of transmitting all data, including trip data, over a two wire local area network to the BACS (refer to Division 15 specifications).

PART 3 - EXECUTION

3.1 INSTALLATION

A. Locations and Layout: Exact locations and physical layout of equipment and components may be varied as required to suit manufacturer's design and as approved, provided the required functions and operations are accomplished; follow the identification of the units indicated on Drawings exactly to ease checking and building maintenance procedures.

B. Equipment Bases: Ensure that concrete bases and foundations provided for installation of equipment are constructed in accordance with approved shop and construction drawings and equipment manufacturers' drawings and that holes for fixing bolts and provisions for passage of cables etc. are provided as required.

C. Cable Trenches: Ensure that trench construction and covers provided for installation of power and control cables are in accordance with approved shop and construction drawings.

D. Built-In Items: Ensure that equipment supports, fixings and the like, and sleeves for passage of feeders and cables which are to be built into concrete foundations, bases, cable trenches or building structure are provided as and when required and that they are properly installed.

E. Equipment: Install on concrete bases etc., and assemble completely plumb and level, before grouting in holding-down bolts.

F. Supports and Terminations: Install all incoming and outgoing cable supports, cable ends and termination fittings required for MV, LV and control cables.

G. Relays: Set in accordance with manufacturer's instructions and the Local Power A's requirements.

H. Earthing: Ensure that earthing installation is as described in Division 16 Section "Grounding and Bonding" of the Specification and/or as shown on the Drawings.

I. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, brackets, and temporary blocking of moving parts from switchgear units and components.

3.2 IDENTIFICATION

A. Identify field-installed wiring and components and provide warning signs as specified in Division 16 Section "Basic Electrical Materials and Methods."

B. Diagram and Instructions: Frame under clear acrylic plastic on the front of switchgear.

1. Operating Instructions: Printed basic instructions for switchgear, including control and key-interlock sequences and emergency procedures.
2. Storage for Manual: Include a rack or holder, near the operating instructions, for a copy of the maintenance manual.
3. System Power Riser Diagrams: Depict power sources, feeders, distribution components, and major loads.

3.3 CONNECTIONS

A. Tighten bus joint, connector, and terminal bolts according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in applicable Standards.

3.4 FACTORY WITNESS TEST

A. Factory inspection visits are to cover complete checking and testing of selected units according to requirements of the specified regulations and standards as well as special requirements finishes, software and controls. Inspection visits are also to cover spot checking of manufacture work progress to ensure conformance of the equipment being fabricated with the requirements of the contract. Inspection and test procedures and programs are to be submitted for approval prior to factory visit.

B. Factory visits are to include for business class air tickets, five star hotel full accommodation, transportation and all inspections/test expenses

C. Provide 3 man-visit to cover all types of tests including complete assembled switchgear...

3.5 FIELD QUALITY CONTROL

A. Equipment: Inspect equipment upon delivery to site and report any damage to the Engineer.

B. Switchgear: Inspect and check switchgear for completeness and as recommended by the manufacturer and check phasing of buses, contact alignment and clearances.

C. Components: Check component ratings, types, sizes and wiring connections, including current and voltage transformers, fuses, switches, instruments and relays.

D. Before energization carry out at least the following tests:

1. Insulation resistance on busbars (with circuit breakers in disconnected position), circuit breakers, bushings and insulators, feeder terminals etc., using at least a 5 kV megger for MV circuits and a 1000 V megger on all control and protection circuits, with relays, lamps and the like components disconnected, to ensure satisfactory insulation resistance as recommended by the Standards and approved practices.
2. High voltage tests on busbars, circuit breakers in disconnected position, switches, VTs and insulators, by applying HV a.c. test voltage between phases and phase to earth at 80% of the IEC voltage withstand test for 1- minute.
3. Resistance across closed contacts of circuit breakers using appropriate micro-ohm meter.
4. Polarity check and ratio tests for CTs.
5. Calibration checks and adjustment for ammeters and voltmeters.
6. Primary and/or secondary injection tests to check relay operation, using appropriate test sets, followed by tripping of circuit-breaker once only, through its protective relay circuit.

E. Cables: With circuit breaker in disconnected position, ensure that HV testing of feeder cable and respective termination is carried out as required under cable tests.

F. After energization carry out inspection and checking as follows:

1. Breakers are to be closed, one at a time, with as little load on the feeder as possible; check meters as load is increased and any indication of overheating detected by appropriate instruments or sensors.
2. Open and withdraw circuit breaker after a prolonged test run, inspect and check circuit breaker conditions, isolating contacts, contacts on all instruments and control switches, connections at terminal blocks etc., busbar connections and busbars for any indication of overheating; check for loose connections and bolts etc. and finally re-apply megger tests to ensure same quality of insulation as before energization.
3. Close circuit breaker slowly, while in the disconnected position and inspect contacts and/or contact movement and compare with design figures.

G. Manufacturer's instructions are to be followed under all circumstances. Carry out and record measurement and tests recommended by the manufacturer.

H. Infrared Scanning: After Substantial Completion, but not more than two months after the end of the Defects Liability Period, perform an infrared scan of switchgear assembly. Make bus joints and connections accessible to a portable scanner and perform scanning during a period of normal working load as advised by Employer.

1. Follow-up Infrared Scanning: Perform one additional follow-up infrared scan at same locations as before, 11 months after date of Substantial Completion.
2. Instrument: Use an infrared-scanning device designed to measure temperature or detect significant deviations from normal values. Provide calibration record for scanning device used for electrical distribution equipment.
3. Record of Infrared Scanning: Prepare a certified report identifying all connections checked and describing results of scanning. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.6 CLEANING

A. Inspect interior and exterior of installed switchgear. Remove paint-splatters and other spots, dirt, and debris. Touch up scratches and mars of finish to match original finish.

3.7 DEMONSTRATION

A. Train Employer's maintenance personnel to adjust, operate, and maintain the system installation. Refer to Division 1

END OF SECTION 10014

SECTION 10015 - POWER TRANSFORMERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Conditions of Contract and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes distribution and power transformers with medium-voltage primaries.

B. Related Sections include the following:

1. Division 100 Section "Basic Electrical Materials and Methods".
2. Division 100Section "Secondary Unit Substations" for transformers integral to substations.
3. Division 100 Section "Busways" for busway connections between transformers and secondary distribution equipment.
4. Division 16 Section "Medium-Voltage Cables" for cable terminations at transformers.

1.3 SUBMITTALS

A. Product Data: Include full technical data on features, components, ratings, and performance for each type of transformer specified. Include dimensioned plans, sections, and elevation views. Show minimum clearances and installed devices and features. Submit Manufacturers' catalogues.

B. Wiring Diagrams: Detail wiring and identify terminals for tap changing and connecting field-installed wiring.

C. Product Certificates: Signed by manufacturers of transformers certifying that the products furnished comply with requirements.

D. Type Test Certificates: Submit to verify compliance of main equipment with the relevant IEC Standards.

E. Routine Tests: Each transformer unit is to undergo routine tests at the manufacturer's works in accordance with the relevant standards. Submit routine test reports, prior to shipping equipment, indicating ambient test conditions and guaranteed rating of equipment under site conditions.

F. Shop and Construction Drawings: Submit drawings for approval including, but not limited to, the following:

1. Plans and elevations, with dimensions and weights.
2. Arrangement of equipment and general layouts.
3. One-line diagram of power system.
4. Foundation details, grouting holes and installation details.

G. Sound-Level Test Reports: Certified copies of manufacturer's sound-level tests applicable to equipment for this Project.

H. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.

I. Maintenance Data: For transformers to include in the maintenance manuals specified in Division 1.

1.4 QUALITY ASSURANCE

A. Manufacturer Qualifications: Engage a firm experienced in manufacturing transformers similar to those indicated for this Project and with a record of successful in-service performance.

B. Standards: Equipment and component parts are to comply with the following Standards:

1. Common clauses for HV switchgear and control gear standards: IEC 60694.
2. Power transformers: IEC 60076, 60354, 60726.
3. Insulating oil: IEC 60296.

1.5 WARRANTY

A. Manufacturers Warranty: Submit a written warranty signed by the manufacturer agreeing to repair, restore or replace any defective equipment specified in this section during the specified warranty period

1. Warranty Period: 1 year from date of substantial completion.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Temporary Heating: For indoor, dry-type transformers, apply temporary heat according to manufacturer's written instructions within the enclosure of each ventilated-type unit throughout periods during which equipment is not energized and is not in a space that is continuously under normal control of temperature and humidity.

1.7 COORDINATION

A. Coordinate layout and installation of transformers with other construction.

B. Coordinate size and location of concrete or mounting bases. Concrete, reinforcement, and formwork requirements are specified in Division 3 Section "Cast-in-Place Concrete."

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Approved Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

1. A.B.B.
2. Cuttler Hammer
3. France Trafo
4. G.E.
5. GEC Alsthom
6. Pauwels
7. Siemens
8. Square D; Groupe Schneider.
9. Trafo-Union

Country of origin is to be submitted for review/approval.

Complete documentation for the factory manufacturing the equipment is to be submitted including but not limited to, local and international experience, quality certificates, quality assurance plan, and organization .

2.2 DRY TYPE CAST RESIN POWER TRANSFORMER

A. Type: 3-phase, indoor type, two winding, solventless cast epoxy resin, vacuum pressure impregrated windings, with minimum class F insulation on inner LV cores and class B on outer MV cores, rated for continuous operation under worst site ambient conditions at full load, and complying with IEC 60726. Temperature rise is not to exceed 70 deg. C over an average ambient of 40 deg. C for class B insulation and 90 deg. C over an average ambient of 40 deg. C for class F insulation.

B. Insulation and Encapsulation: Humidity resistant, explosion and fire-resistant, self-extinguishing, tropicalized, giving non-toxic gases in the event of fire.

C. Tapping is to be provided on MV side by means of re-connectable links (off-circuit), giving +/-2.5% and +/-5% tapping.

D. Rubber sound isolation pads are to be provided between core and coil assemblies, and between base and housing.

E. Cooling fans, where specified, are to permit 30% increase in rated power.

F. Mounting and Handling: Transformer base and structure are to have lifting hooks or lugs, towing and lashing eyes or lugs and provision for roller wheels.

G. Temperature monitoring is to be provided by externally mounted tripping units giving alarm and trip at two stages with about 20 deg. C temperature difference, actuated by three embedded thermistor sensors in LV windings (hot-spot). Additional thermal monitoring/control is to be provided for cooling fan operation.

H. Terminals: Arranged as described in paragraph 2.2J hereof and/or as shown on the Drawings, and are to be compatible for copper or aluminum cable termination.

I. Earthing bolts or copper pads are to be provided on main frame of transformer. Earthing busbars are to be provided on LV and MV sides of housing.

J. Housing: Sheet steel construction, IP 21 with provision for roof fans for indoor installation,

K. Characteristics:

1. Rated Power (net without fans): . as shown on drawings
2. Frequency: 50 Hz.
3. Rated Voltage:
   a. MV Side (primary): 22 kV, 24 kV insulation level.
   b. LV Side (secondary): 380 V.
4. Winding Connections: Dy11 neutral insulated and brought out.
5. Impedance Voltage at Rated Current: 6.3 %.
6. Rated Power Frequency Withstand-Voltage: 50 kV.
7. Lightning Impulse Withstand-Voltage: 125 kV.
8. Short-Circuit Apparent Power of the System at Location: 500 MVA.
9. Duration of Short-Circuit-Withstand: 2 seconds.
10. Terminal Connection System:
    a. MV Side: cable sealing ends, bolted, from below.
    b. LV Side: cable glands and fittings, bolted, from below.

L. Accessories are to include the following:

1. Earthing switch, fault-making type, on MV side of housing, interlocked with door, visible from outside the enclosure, with trip contact for tripping MV circuit breaker before closing earthing switch.
2. Fans and fans control for extra rating of transformer.
3. Four re-orientable roller rim wheels and attachment accessories.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Locations and Layout: Exact locations and physical layout of equipment and components may be varied as required to suit manufacturer's design and as approved, provided the required functions and operations are accomplished; follow the identification of the units indicated on Drawings exactly to ease checking and building maintenance procedures.

B. Equipment Bases: Ensure that concrete bases and foundations provided for installation of equipment are constructed in accordance with approved shop and construction drawings and equipment manufacturers' drawings and that holes for fixing bolts and provisions for passage of cables etc. are provided as required.

C. Cable Trenches: Ensure that trench construction and covers provided for installation of power and control cables are in accordance with approved shop and construction drawings.

D. Built-In Items: Ensure that equipment supports, fixings and the like, and sleeves for passage of feeders and cables which are to be built into concrete foundations, bases, cable trenches or building structure are provided as and when required and that they are properly installed.

E. Equipment: Install on concrete bases etc., and assemble completely plumb and level, before grouting in holding-down bolts.

F. Supports and Terminations: Install all incoming and outgoing cable supports, cable ends and termination fittings required for MV, LV and control cables.

G. Relays: Set in accordance with manufacturer's instructions and the Local Power Authorities requirements.

H. Earthing: Ensure that earthing installation is as described in Division 16 Section "Grounding and Bonding" of the Specification and/or as shown on the Drawings.

I. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, brackets, and temporary blocking of moving parts from switchgear units and components.

3.2 IDENTIFICATION

A. Identify transformers and install warning signs according to Division 16 Section "Basic Electrical Materials and Methods."

3.3 CONNECTIONS

A. Tighten bus joint, connector, and terminal bolts according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in applicable Standards.

3.4 FACTORY WITNESS TEST

A. Factory inspection visits are to cover complete checking and testing of selected units according to requirements of the specified regulations and standards as well as special requirements finishes, software and controls. Inspection visits are also to cover spot checking of manufacture work progress to ensure

conformance of the equipment being fabricated with the requirements of the contract. Inspection and test procedures and programs are to be submitted for approval prior to factory visit.

B. Factory visits are to include for business class air tickets, five star hotel full accommodation, transportation and all inspections/test expenses

C. Provide 4 man-visit to cover all types of tests .

3.5 FIELD QUALITY CONTROL

A. Equipment: Inspect equipment upon delivery to site and report any damage to Engineer.

B. Components: Check component ratings, types, sizes and wiring connections, including current and voltage transformers, fuses, switches, instruments and relays.

C. Manufacturer's instructions are to be followed under all circumstances. Carry out and record measurement and tests recommended by the manufacturer.

D. Test Objectives: To ensure transformer is operational within industry and manufacturer's tolerances, is installed according to the Contract Documents, and is suitable for energizing.

E. Test Labeling: On satisfactory completion of tests for each transformer, attach a dated and signed "Satisfactory Test" label to tested component.

F. Schedule tests and provide notification at least 7 days in advance of test commencement.

G. Report: Submit a written report of observations and tests. Report defective materials and installation.

H. Tests: Include the following minimum inspections and tests according to manufacturer's written instructions.

1. Inspect accessible components for cleanliness, mechanical and electrical integrity, and damage or deterioration. Verify that temporary shipping bracing has been removed. Include internal inspection through access panels and covers for dry-type transformers.
2. Inspect bolted electrical connections for tightness according to manufacturer's published torque values.
3. Insulation Resistance: Perform meg-ohmmeter tests of primary and secondary winding to winding and winding to ground.
4. Duration of Each Test: 10 minutes.
5. Temperature Correction: Correct results for test temperature deviation from 20 deg C standard.
6. Turns Ratio: Measure between windings at each tap setting. Measured ratios deviating more than 0.5 percent from calculated or measured ratio for an adjacent coil is not acceptable.
7. Winding Resistance: Measure for windings at nominal tap setting. Measured resistance, deviating more than 1 percent, from that of adjacent windings, is not acceptable.
8. Liquid-Filled Transformer, Insulation Power-Factor Test: Determine overall dielectric loss and power factor for windings' insulation. Limit test` voltage to line-to-ground voltage of windings being tested.
9. Electro-magnetic interference: measure the level of the electro-magnetic interference in the transformer room, take necessary measures to limit the electro-magnetic waves level to the levels recommended by the standards.

I. Test Failures: Compare test results with specified performance or manufacturer's data. Correct deficiencies identified by tests and retest. Verify that transformers meet specified requirements.

3.6 GROUNDING

A. Comply with Division 16 Section "Grounding and Bonding" for materials and installation requirements.

3.7 CLEANING

A. On completion of installation, inspect components. Remove paint splatters and other spots, dirt, and debris. Repair scratches and mars on finish to match original finish. Clean components internally using methods and materials recommended by manufacturer.

3.8 ADJUSTING

A. After installing and cleaning, touch up scratches and mars on finish to match original finish.

B. Adjust transformer taps to provide optimum voltage conditions at utilization equipment throughout normal operating cycle of facility. Record primary and secondary voltages and tap settings and submit with test results.

3.9 DEMONSTRATION

A. Train Employer's maintenance personnel to adjust, operate, and maintain the system installation. Refer to Division 1

END OF SECTION 10015