SECTION 14A

GENERAL IN MECHANICAL WORK

1. GENERAL

The general arrangement of the mechanical work shall be as indicated. Detailed drawings of proposed departures due to actual field conditioning or other causes shall be submitted for approval. The Contractor shall carefully examine the drawings and shall be responsible for the proper fitting of materials and equipment in the building, as indicated, without substantial alteration. Material and equipment installed in the mechanical work shall be suitable for the pressures and temperatures encountered. Unless otherwise specified, all materials, methods, and details of mechanical work shall comply with the latest editions of the following recommendations, specifications or standards.

- International Standard Organization (ISO)
- Japanese Industrial Standards (JIS)
- British Standards (B.S.)
- American Society of Testing and Materials (ASTM)
- American Society of Heating, Refrigerating and Air-Condition Engineers (ASHRAE) Standards
- American Society of Mechanical Engineers (ASME) Codes
- National Fire Protection Association (NFPA) Standards

2. UTILITIES

City water service piping shall be connected to the city water service main as shown on the drawing. Sewer and water pipes shall be laid in separate trenches, except when otherwise shown.

3. CROSS CONNECTIONS AND INTERCONNECTIONS

No plumbing fixture, device, equipment, or pipe connection shall be installed that will provide a cross connection or interconnection between a potable water supply and any source of nonpotable water, such as a sea water system or a drainage system or a soil or waste pipe.

4. CONNECTIONS TO EQUIPMENT AND FIXTURES

The Contractor shall provide all necessary material and labour to connect to the plumbing system all fixtures and equipment having plumbing connections. Drainage connections shall be trapped. The supply line to each item of equipment or fixture, except faucets, flush valves, or other control valves which are supplied with an integral stop, shall be equipped with a cutoff valves to enable isolation of the item for repair and maintenance without interfering with operation of other equipment of fixtures.

5. NAMEPLATES

Each major component of equipment shall have the manufacturer's name, address, and catalogue number on a plate securely attached to the item of equipment.

6. SAFETY REQUIREMENTS

Belts, pulleys, chains, gears, couplings, projecting setscrews, keys, and other rotating parts located so that any person can come in close proximity thereto shall be fully enclosed or properly guarded. Items such as catwalks, ladders, and guardrails shall be provided where required for safe operation and maintenance of equipment.

7. SPARE-PARTS DATA

As soon as practicable after approval of the list of equipment, the contractor shall furnish spare-parts data for each different item of equipment listed. The data shall include a complete list of parts and supplies, with current unit prices and source of supply.

8. VERIFICATION OF DIMENSIONS

The contractor shall be responsible for the coordination and proper relation of his work to the building structure and to the work of all trades.

9. CUTTING AND REPAIRING

The work shall be carefully laid out in advance, and no excessive cutting of construction will be permitted. Damage to buildings, piping, wiring, or equipment as a result of cutting for installation shall be repaired by mechanics skilled in the trade involved.

10. PROTECTION TO FIXTURES, MATERIALS, AND EQUIPMENT

Pipe openings shall be closed with caps or plugs during installation. Fixtures and equipment shall be tightly covered and protected against dirt, water, and chemical or mechanical injury. Upon completion of all work, the fixtures, materials, and equipment shall be thoroughly cleaned, adjusted, and operated.

11. DRAWINGS

Because of the small scale of the drawings, it is not possible to indicate all offsets, fittings, and accessories that may be required. The Contractor shall carefully investigate the structural and finish conditions affecting all his work and shall arrange such work accordingly, furnishing such fittings, traps, valves, and accessories as may be required to meet such conditions.

12. MATERIALS, FIXTURES, AND EQUIPMENT

Materials, fixtures, and equipment shall be as specified herein and as shown on the drawings. Fixtures and equipment shall be the products of manufacturers regularly engaged in the manufacture of such products. Fixtures and equipment differing in minor respects from that specified may be proposed, provided such differences are clearly stated.

13. APPROVAL OF MATERIALS, FIXTURES, AND EQUIPMENT

Before starting installation of any materials or equipment the Contractor shall submit to the Engineer for approval, in triplicate, layout drawings and lists of materials, fixtures, and equipment to be incorporated in the work. The layout drawings shall consist of plans drawn to scale, with elevations and sections to show clearly the location and size of major items of equipment and large piping, and clearances of maintenance withdrawal of removal components. If departures from the contract drawings are deemed necessary by the Contractor, details of such departures, including changes in related portions of the project and the reasons therefor, shall be submitted with the drawings. Where such departures require piping or equipment to be supported, the details submitted shall include leadings and type and kinds of frames, brackets, stanchions, or other supports necessary. Approved departures shall be made at no additional cost. The lists of materials and equipment shall be supported by sufficient descriptive material, such as catalogues, cuts, diagrams, and other data published by the manufacturer, as well as evidence of compliance with safety and performance standards, to demonstrate conformance to the requirements. The data shall include the name and address of the nearest service and maintenance organization that regularly stocks repair parts.

14. SHOP DRAWINGS

After receiving tentative approval of the items on the materials and equipment lists, and before installation of any of these items, the Contractor shall submit 4 copies of complete shop drawings and such other descriptive data. Approval of the submitted drawings and lists will be promptly acted upon. However, if materials or equipment are installed prior to approval, the Contractor shall be liable for the removal and replacement of any such item not approved at no additional cost to other Owner. All work shall be accurately laid out with reference to the architectural drawings and in co-operation with other trades. Shop drawings shall be submitted for the following items at one time in order to demonstrate that these items of equipment have been properly coordinated and will function properly with each other:

City water and sea water pumps
City water reservoir and elevated tanks
Septic tank and soak away
Sea water filtration system
Direct expansion fan-coil units and air cooled condensers
Wall thru type room air conditioners
Fans
Plumbing fixtures and fittings
Walk-in refrigerator
Rotary blowers

Shop drawings shall be submitted also the following items:

Pipes and fittings, valves, air ducts and supports, diffusers, dampers, grilles, registers, insulation, and such other items as may be directed.

15. SAMPLES

All samples requested by the Owner or the Engineer shall be promptly submitted.

16. ELECTRICAL WORK

Electric-motor-driven equipment specified herein shall be provided complete with motor and motor starters. Electrical equipment and wiring shall conform to Section: ELECTRICAL WORK. Electrical characteristics shall be as indicated. Motor starters shall be provided complete with properly sized thermal-overload protection and other equipment at the specified capacity including an allowable service factor, and other appurtenances necessary for the motor control. Manual or automatic control and protective or signal devices required for operation and any wiring required but not shown on the electrical drawings shall be provided under this section of the specifications.

A complete electrical-connection diagram for each piece of mechanical equipment and automatic or manual electrical-control device shall be submitted for approval. Motors shall be suitable for use in ambient temperatures of 50-degrees C. and shall be capable of the required characteristics indicated on the drawings.

17. PAINTING

17.1 Except as otherwise specified, pipe hangers, structural supports, pipe and pipe fittings, ducts, and all metal surfaces associated with mechanical equipment shall be painted utilizing the painting systems as specified hereinafter. Finish paint in areas having painted adjacent surfaces shall match the adjacent surfaces. Ferrous piping in unpainted areas shall be given two coat of asphalt varnish. Steel and wrought-iron pipe which has an undamaged factory-applied bituminous varnish protective coating shall require no further protection. Bare pipe and fittings with factory-applied bituminous varnish protective coating shall require no further protection. Bare pipe and pipe on which factory-applied protective coating is damaged and the pipe surface shows rusting shall be cleaned to bare metal and then painted with one coat of pretreatment coating applied to a dry film thickness of 0.3 to 0.5 mil, and two coats of zinc chromate primer, each coat applied to a minimum dry film thickness of 1.0 mil. Equipment shall be finished in accordance with the specification for the particular end item. Surfaces on factory-finished equipment that are damaged during installation shall be restored to their original condition.

17.2 Metal surfaces, external (not shop-primed)

Metal surfaces, external (not shop-primed), except structures requiring special paint systems, shall be primed with one coat of red-lead paint conforming to BS 2523: 1966 applied to a minimum dry film thickness of 1.0 mil, and finished with two coats of external alkyd oil paint, each coat applied to a minimum dry film thickness of 1.5 mils.

17.3 Metal, internal, (not shop-primed), surfaces shall be painted with a three-coat system as follows:

(a) Primer

One coat of zinc-chromate primer conforming to BS 4652: 1971 applied to a minimum dry film thickness of 1.0 mil.

(b) Intermediate

One coat of internal flat odorless alkyd paint for under flat odorless alkyd paint, and internal enamel undercoat for under glass enamel, applied to a minimum dry film thickness of 1.0 mil.

(c) Finish

One coat of internal flat odorless alkyd paint or internal oilpaint applied to a minimum dry film thickness of 1.5 mils.

(d) Piping identification shall conform to the requirements of BS 1710: 1971. Stenciling shall be placed in clearly visible locations. All piping not covered by the a forementioned standard shall be stenciled with names or code letters approved by the Engineer, not less than 12 mm (1/2 in.) high for piping and not less than 50 mm (2 in.) high elsewhere. Arrow-shaped markings shall be painted on the lines to indicate the direction of flow. Two copies of the complete colour and stencil codes used shall be provided; they shall be framed under glass and shall be installed where directed by the Engineer.

(e) Other surfaces for which the type of paint has not been specified shall be painted as specified for surfaces having similar conditions of exposure.

(f) Inspection

Surface preparation, application procedures, and material selection will be examined by the Engineer to determine conformance with the requirements specified. Each separate operation shall be approved prior to initiation of subsequent operations.

18. WORKMANSHIP/INSTALLATION

18.1 Consider that applicable manufacturer's detailed directions governing thinners, solvents and related materials, paint storage, surface preparation, application conditions and techniques, dry film thickness, temperature and ventilation requirements before, during and after application. Finished surface protection and touch-up are herein included. Deliver materials to site in original, unopened containers clearly marked with manufacturer's brand, contents and grade.

18.2 Apply only colours selected by Engineer; prepare and submit selected samples to Engineer for prior approval of colour and texture. Tint successive paint coats sufficiently to differentiate between coatings; use only tints compatible with applicable paints.

18.3 Temporarily remove or mask all furnish hardware, electric plates and fixtures, factory finished surfaces and glass immediately prior to paint application; clean areas not specified for painting, leaving sharp, straight demarcation lines.

18.4 Apply no protective coatings over dirty, rusted, oily, wet or greasy surfaces, over undried, retted, or unsound wood or over loose, undried or uncured previous applications; apply no paint over concrete, plaster, stucco or concrete block when moisture meter indicates 8 or above; apply no paint over wood when moisture meter indicates 12 or above.

19. OPERATING AND MAINTENANCE INSTRUCTIONS

Six complete sets of instructions containing the manufacturer's operating and maintenance instructions for each piece of equipment shall be furnished. Each set shall be permanently bound and shall have a hard cover. The instructions shall include, but shall not be limited to, the following:

System layout.

Wiring and control diagrams, with data to explain the detailed wiring and control of each component.

A description of startup, operation and shutdown.

Manufacturer's bulletins, cuts, and descriptive data.

Parts lists and recommended spare parts.

20. GUARANTEE

The equipment to be furnished under this section of the specifications shall be guaranteed for a period of 1 year from the data of acceptance against defective materials and workmanship. Upon receipt of notice of failure of any part of the guaranteed equipment during the guarantee period, the affected part or parts shall be replaced promptly with new parts by and at the expense of the Contractor.

SECTION 14B

PLUMBING

1. WATER PIPE, FITTING, AND CONNECTIONS

1.1 City water service pipe to the building up to and including 80mm diameter shall be galvanized steel pipe Schedule 40 screw-jointed and pipes 100mm and larger in diameter shall be asbestos cement pipe or approved materials by Water Supply Department.

1.2 Potable water pipe shall be galvanized steel pipe Schedule 40 screw-jointed.

1.3 Hot water pipe shall be type L copper tubing.

1.4 Exposed cold-and hot-water-supply piping to fixtures shall be chrome-plated brass pipe.

1.5 Fitting shall be compatible with the pipe material. Fittings for galvanized steel pipe shall be the threaded type and for copper-tubing shall be the solder-type bronze or wrought copper.

1.6 Installation

Piping shall be installed as indicated. Pipe shall be cut accurately to measurements established at the building by the Contractor and shall be worked into place without springing of forcing. Care shall be taken not to weaken structural portions of the building. Piping shall be run parallel with the lines of the building unless otherwise indicated. Branch pipes from service lines may be taken from top, bottom, or side or main, using such crossover fittings as may be required by structural or installation conditions. Supply pipes, valves, and fittings shall be kept a sufficient distance from other work and other services to permit not less than 15 mm between finished covering on the different services. Changes in pipe sizes shall be made with reducing fittings. Use of bushings will not be permitted. Change in direction shall be made with fittings.

1.7 Joints

Installation of pipe and fittings shall be made in accordance with the manufacturers' recommendations. Mitering of joints for elbows and notching of straight runs of pipe for tees will not be permitted.

(a) Threaded joints shall be cut with an approved threadcutting oil. Joints shall be made tight with a stiff mixture of litharge and glycerin or other approved thread-joint compound applied with a brush to the male threads only. Not more than three threads shall show after the joint is made up.

(b) Flared or sweated tubing shall be cut square, and burs shall be removed. Outside of tube where engaged in the fitting and inside of the fitting in contact with tube shall be cleaned with an abrasive material before sweating. Care shall be taken to prevent annealing of tube and fittings when making connections. Joints shall be made with a non-corrosive paste flux and solid-string or wire solder. Core solder will not be permitted. Flared joints shall be made using flared fittings.

2. VALVES

Valves shall be provided on supplies to equipment or fixtures. No valve shall be installed on any line with its stem below the horizontal. All valves shall be gate valves. Valves up to and including 50 mm shall be all brass with threaded ends, and sweat-type connections for tubing. Valves 65 mm and larger in diametre shall have iron bodies, bronze trim, and either screw or flange ends; and shall be cast bronze with sweat-type connections for installation with tubing.

3. UNIONS

Unions on water piping 65 mm in diametre and larger shall be flange pattern. Gaskets for flanged unions shall be of the best quality fibre, plastic, or leather. Unions shall not be concealed in walls, ceiling or partitions.

4. FLEXIBLE JOINTS

The body of the flexible joint shall be stainless steel tube or copper with bellows type construction, and the assembly shall be reinforced with stainless steel wire braid or strip, having sufficient flexibility and rated for a working pressure of 10 Kg/cm^2.

5. SOIL, WASTE, DRAIN AND VENT PIPING

Soil, waste and drain pipe and fittings shall be polyvinyl-chloride pipe schedule 40. Fittings for soil, waste, and drain pipes shall be of the drainage-pattern type and shall be compatible with the pipe material except where adapters are required for interconnection of different pipe materials. Fittings on dry vents shall be regular-pattern type.

5.1 Installation

(a) Drainage and vent pipes

Horizontal soil and waste pipes shall have a grade of 20 mm per metre. When authorized, horizontal piping of 100 mm nominal diametre of larger may be installed with a fall not

less than 10 mm per meter. Main vertical soil and waste stacks shall be extended full size to the roofline and above as vents, except where otherwise indicated. Where practicable, two or more vent pipes shall be connected and extended as one pipe through the roof. Where a circuit vent pipe from any fixture or line of fixtures is connected to a vent line serving other fixtures, the connection shall be at least 150 mm above the flood-level rim of the highest fixture served to prevent the use of any vent line as a waste. Vent and branch-vent pipes shall be so graded and connected as to drip back to the vertical stack by gravity. Vent pipe shall be taken out from drainage branches vertically or with 45° angle but shall not be taken out horizontally. The meeting points of lateral soil and waste branches, the pipe shall be jointed horizontally with an angle less than 45°.

(b) Fitting shall be compatible with pipe material. Changes in pipe size on soil, waste, and drain lines shall be made with reducing fittings. Changes in direction shall be made by the appropriate use of 45-degree wyes, long- or short-sweep 1/4 bends, 1/6, 1/8, or 1/16 bends or elbows, or by a combination of those or equivalent fittings. Single and double sanitary tees and 1/4 bends or elbows may be used in drainage lines only where the direction of flow is from horizontal to vertical, except elbows 50 mm or less in diametre may be used. Short sweeps not less than 75 mm in diametre may be used where the change in direction of flow is either from horizontal to vertical or from vertical to horizontal, and may be used for making necessary offsets between the ceiling and the next floor above.

(c) Union connection

Slip joints will be permitted only in trap seals or on the inlet side of the traps. Tucker or hub drainage fittings shall be used to make union connections wherever practicable.

5.2 Joints

Installation of pipe and fittings shall be made in accordance with the manufacturer's recommendations. Mitering of joints for elbows and notching of straight runs of pipe for tees will not be permitted.

(a) Plastic pipe

Joints for polyvinyl-chloride pipe and fittings shall be made using solvent cement. Threaded joints shall be used only where required for disconnection and inspection.

6. PIPE CLEANOUTS

Pipe cleanouts shall be the same size as the pipe except that clean-out plugs larger than 100 mm will not be required. Cleanouts in connection, where indicated, shall be T-pattern, 90-degree branch drainage fittings with screw plugs of the same size as the pipe up to and including 100 mm. Cleanout tee branches with screw plug shall be installed at the foot of soil and waste stocks, at the foot of internal downspouts are indicated, and on each building drain outside the building. Cleanout plugs for metallic pipe shall be cast brass. Cleanouts on pipe concealed in partitions and walls shall be provided with chromium-plated cast-brass covers secured to plugs.

7. FLASHINGS

Pipes passing through waterproofing membrane shall be flashed. A sheetlead flashing shield shall be provided for drains and pipe sleeves with integral clamping devices that penetrate a membrane. Flashing shield shall be made from not lighter than 1.8 Kg sheet lead and extend not less than 200 mm from the drain or sleeve in all directions. Flashing shall be inserted into the clamping device and made watertight. Lead flashing shields, and roof flanges of lead or copper flashing with integral flange, shall be set over membrane in a soiled coat of bituminous cement and strip-flashed.

8. TRAPS

Each fixture and piece of equipment requiring connections to the drainage system, except grease interceptors, shall be equipped with a trap. Each trap shall be placed as near the fixture as possible, and no fixture shall be double-trapped.

9. DRAINS

The size of the drains shall be determined by the branch sizes indicated. Drains installed in connection with waterproofed floors shall be equipped with bolted-type clamping devices.

9.1 Drain for floor and shower shall be of heavy cast iron, double drainage pattern, with perforated or slotted stainer of chromium-plated cast brass threaded or calked outlet connection. A suitable clamp shall be furnished when attaching to waterproofing membrane.

9.2 Indirect sight drains shall be with a brass funnel strainer, so installed that the direct waste will terminate 50 mm above the flood rim of the funnel to provide an acceptable airgap. A brass funnel shall be securely mounted over an opening in the centre of the strainer.

10. ELECTRIC HOT WATER HEATERS

The size, capacity, voltage and combined wattage of heating elements shall be not less than indicated. Wiring shall be so arranged that, when required by thermostats, both heating elements will operate simulataneously. Electric hot water heaters shall include a thick blanket of insulation between inner and outer shells. Heating elements shall be "nichrome" immersion type imbedded in magnesium oxide and sealed in seamless copper tubing. The electric heaters shall be factory wired with a high temperature cut-off and shall be complete with a thermometer, drain valve, temperature-pressure relief valve. Electric water heaters with bottom supply connections shall be provided with a vacuum relief valve on the cold water supply line at an elevation above the top of the tank.

11. WATER TANKS

Water tanks shall be constructed of unsaturated polyester reinforced with glass fibre (herein called F.R.P.) prefabricated panel as shown on the drawings.

Unsaturated polyester resin shall have excellent waterproofing and weather resisting characteristics and not harmful to health and water quality.

The tank shall be provided with fittings for connections of water filling pipe, water supply pipe, drain pipe, overflow pipe, vent pipe, electrode and ripple proof baffle board, manhole and FRP or steel ladders. Vent and overflow pipe shall be provided with plastic insect screen. Water tanks shall be similar or equal to "SEKISUI KOJI CO., LTD." (5-2, Dojima 1-chome, Kita-ku, Osaka, Japan, Telex: J 648-96 SEKIKOJI, International Phone: +81.6.344. 9251) of type and size as shown on the drawings and shall be of approved by the Engineer.

11.1 City water reservoirs shall have a storage capacity of 16 m^3 (3,550 imp. gallons). The reservoir foundation shall have sufficient bearing surface to support the weight of tank, when full, filled with water and without any distortion at the bottom plate of the reservoir. Piping shall be properly supported to avoid the piping loads depending upon the reservoirs. Piping shall be connected to reservoir by flexible joints except over flow pipe, vent pipe and blow off pipe.

11.2 Header tanks shall have a storage capacity as indicated on drawings. The elevated tank foundation shall have sufficient bearing surface to support the weight of tank, when filled full with water and without any distortion at the bottom plate of the tank, and shall be mounted on the base in a manner sufficiently to resist wind loads and other impacts. Piping shall be properly supported to avoid the piping loads depending upon the tank. Piping shall be connected to tank by flexible joints except overflow pipe, vent pipe and blow off pipe.

12. WATER PUMPS

Water pumps shall be the horizontal, centrifugal, multi-stage type and shall be direct-connected to the electric motors through flexible couplings. Each pump and electric motor shall be mounted on a common base arranged for bolting to a concrete foundation. The pumps shall be designed for waterworks service, with flanged suction and discharge nozzle on opposite sides of the pumps. Pumps shall be capable of discharging the quantities against the total heads indicated. The efficiency of each pump when operating under the conditions of the specified capacities and heads shall be as near its peak efficiency as practicable. Pump casings shall be of cast iron, of horizontal-split design. Impellers shall be of the inclosed type, of bronze, statically and hydraulically balanced. Wearing rings of bronze shall be provided for impellers. Shaft shall be of stainless steel or carbon steel, accurately machined, and shall be of sufficient size and strength for the work required. Bronze shaft sleeves shall be provided for carbon steel shaft for protection of shaft in contact with water, and in stuffing boxes. Shaft sleeves shall be keyed to the pump shaft. Stuffing boxes shall be water-sealed, and shall be designed to insure tight packing without excessive wear or friction on the shaft sleeve, and to prevent air leakage into the pump under all conditions of operation. Glands shall be the split or solid type, with sufficient room to pack the box,and shall be held in place by swing bolts or other suitable devices. Flexible couplings shall be the heavy-duty type, designed so that the pump shaft may be removed without disturbing the position or adjustment of electric motor. All rotating parts shall operate without excessive thrust, vibration, or noise. Bearings shall be the ball or roller type, designed to handle all radial loads and end thrusts. Base plate shall be of cast iron or welded structural steel, strongly ribbed or reinforced with cross members. The base plate shall have a raised lip, tapped for drainage connections, and lugs drilled to receive the foundation bolts.

(a) Accessories shall be as follows (for each pump):

Common base plate	1 ea
Flexible joint	2 ea
Gate valve	1 ea
Check valve (with by-pass valve)	1 ea
Prime water funnel (with cock)	1 ea
Air cock	1 ea
Drain cock	1 set
Pressure gage (with cock)	1 ea
Connecting flanges (with bolts)	1 set
Anchor bolts	1 set
Wrenches	1 set

(b) Pump foundation shall be concrete with proper strength and bearing surface to support the equipment mounted and shall be constructed on floor slab having the bearing capacity. Surfaces shall be finished with necessary cement mortar.

(c) Valves and pipes shall properly supported so that the load of the valves and pipes will not be directly transmitted to the pump.

13. PIPE SLEEVES, HANGERS, AND FIXTURE SUPPORTS

Pipe sleeves, hangers, and fixture supports shall be furnished and set, and the contractor shall be responsible for their proper and permanent location.

13.1 Pipe sleeves

Pipes passing through concrete or masonry walls or concrete floors shall be provided with pipe sleeves fitted into place at the time of construction. Sleeves shall not be required for waste and soil pipe passing through concrete slab on grade except where penetrating a membrane waterproof floor. Sleeves shall not be installed in structural members except where indicated or approved. All rectangular and square openings shall be as detailed on the drawing. Each sleeve shall extend through its respective wall, floor, or roof, and shall be cut flush, except clamping flanges, with each surface. Sleeves shall be of such size as to provide a minimum of 8 mm all around clearance between bare pipe and sleeves or between jacket over insulation and sleeves. Sleeves in bearing walls, waterproofing membrane floors, and wet areas shall be steel pipe or cast iron pipe. Sleeves in non-bearing walls, floors, or ceilings may be steel pipe, galvanized sheet metal with lock-type longitudinal seam, or moisture-resistant fibre or plastic. Except in pipe chases or internal walls, the annular space between pipe and sleeve or between jacket over insulation and sleeve shall be sealed. Metal jackets shall be provided over insulation passing through external walls, fire walls, fire partitions, floors, or roofs and shall not be less than 0.15 mm thick aluminium, if corrugated, and 0.41 mm-thick aluminium, if smooth, and shall be secured with aluminium or stainless-steel bands not less than 100 mm wide and not more than 200 mm apart.

Where penetrating roofs, before fitting the metal jacket into place, a 15 mm wide strip of sealant shall be run vertically along the inside of the longitudinal joint of the metal jacket from a point below the backup material to a minimum of 990 mm above the roof. If the pipe turns from vertical to horizontal, the sealant strip shall be run to a point just beyond the first elbow. When penetrating waterproofing membrane for floors, the metal jacket shall extend from a point below the backup material to a minimum of 50 mm above the flashing. For other areas, the metal jacket shall extend from a point below the backup material to a point 300 mm above the floor, or when passing through walls above grade shall extend to minimum of 100 mm on either side of the wall.

13.2 Pipes passing through waterproofing membranes

Pipes passing through roof or floor waterproofing membrane shall be installed through a 1.6 mm-thick lead flashing or a 0.055 mm-thick copper flashing, each within an integral skirt or flange. Flashing shall be suitably formed, and the skirt or flange shall extend not less than 200 mm from the pipe and shall set over the roof or floor membrane in a solid coating of bituminous cement. The flashing shall extend up the pipe a minimum of 250 mm. The annular space between the flashing and the bare pipe or between the flashing and the metal-jacket-covered insulation shall be sealed. Flashing for dry vents shall be turned down into the pipe to form a waterproof joint.

13.3 Pipe hangers, inserts, and supports shall be the standard products of manufacturer. Hangers in contact with uninsulated copper tubing or brass pipe shall be electrically coated and shall be sized to suit the outisde diametre of the pipe. Hangers for insulated pipe shall have a diametre large enough to include the insulation, and a protection shield shall be installed with each hanger. The location of hangers and supports shall be coordinated with the structural work to assure that the structural members will support the intended load. Overhead horizontal piping shall be supported with clevis or roll, single or multiple type hangers, rods, inserts, clamps, and other methods of suspension suitable for type of building construction. Horizontal piping which are close to the floor shall be supported with pipe rest and floor flange or pipe roll stand on piers. Horizontal piping adjacent to the wall shall be supported with hooks, hangers suspended from wall brackets or roll stand on wall brackets. Vertical pipes shall be supported with steel pipe clamps, special cast-iron pipe rests, base fittings, or other approved methods of suitable type. In lieu of separate hangers, the contractor may submit for approval a detail drawing of trapeze hangers with turnbuckles on rods and a solid or split-ring clamp which he proposes to furnish for each pipe. Lateral piping shall be supported in accordance with the following table:

Diametre / Type of pipe	Less than 40mm	50 - 80mm	100 - 150mm	Larger than 200mm
PVC Pipe	1.2m	1.5m	1.5m	1.5m
Steel Pipe	1.8	3.0	4.0	5.0
Copper Pipe	1.5	-	-	-

Lateral cast-iron pipe shall be supported at each section of pipe and fitting unless otherwise directed. Vertical steel pipe and cast-iron pipe shall be braced at least one place at each floor, and fixed at the lowest floor slab and at every third floor slab. Vertical polyvinyl-chloride pipe shall be supported at 1.2 m interval.

13.4 Fixture Supports

Wall-hung fixtures shall be fastened to the wall by through-bolts where appearance of the bolts is not objectionable. Exposed bolt heads in finished areas shall be hexagonal and painted. Exposed nuts shall be chromium-plated hexagonal cap nuts. Washers shall be painted or chromium-plated to match bolt heads or nuts.

14. IDENTIFICATION TAGS

Identification tags made of brass, or aluminium, indicating function of the valve, size, and working pressure, shall be installed on all valves except valves installed on supplies at plumbing fixtures. Tags shall be 35 mm minimum in diametre, and marking shall be stamped. Tags shall be wired to valve.

15. FLOOR, WALL AND CEILING ESCUTCHEONS

Escutcheons shall be provided at all finished surfaces where exposed piping, bare or insulated, passes through floors, walls, or ceilings. Escutcheons shall be fastened securely to pipe or pipe covering and shall be chromium-plated iron or chromium-plated brass, either one-piece or split-pattern, held in place by internal spring tension or setscrew.

16. TYPES OF FIXTURES AND FIXTURE TRIMMINGS

Types of fixtures and fixture trimmings indicated on the drawings shall be furnished and installed complete with all trimmings and fittings. Fixtures with the supply discharge below the rim shall be equipped with backflow preventers. Angle stops, straight stops, stops integral with the foucets, or concealed type of lock-shield, loose-key pattern stops for supplies shall be furnished and installed with fixtures. Exposed traps and supply pipes for all fixtures and equipment shall be connected to the rough piping systems at the wall. Floor and wall escutcheons shall be furnished. Exposed fixture trimmings and fittings shall be chromium-plated or nickel-placed brass with polished, bright surfaces.

16.1 Fixture connections

Where space conditions will not permit standard fittings in conjunction with the floor flange, special short radius fittings shall be provided. Connections between earthenware fixtures and flanges on soil pipe shall be made absolutely gastight and watertight with a closet-setting compound or with a neoprene gasket and seal. Use of national-rubber gaskets or putty will not be permitted for these connections. Bolts shall be not less than 8 mm in diametre and shall be equipped with chromium-plated nuts and washers. Fixtures with outlet flanges shall be set the proper distance from floor or wall to make a first-class joint with the closet-setting compound or gasket and fixture used.

16.2 Flush valves shall be of the non-hold-open type.

16.3 Traps

Chromium-plated brass tube P-traps shall be used. Depth of seal water in traps shall be 50 mm.

16.4 Waste fittings

Materials for fittings shall be cast-iron or cast brass and suited for the respective purpose intended. Depth of seal water in traps shall be 50 mm and effective opening of strainers shall not less than the sectional area of the waste pipe.

16.5 Plumbing fixtures and fittings

(a) All fixtures and fittings shall be new and unused. Plumbing fixtures and fittings indicated on the drawings are "Armitage Shanks Sales, Ltd." products unless otherwise shown. Other manufacturer's standard products may be approved by the Engineer on an "or approved equal" basis.

(b) Installation of brackets and backhangers necessary for mounting fixtures to concrete masonry unit walls shall be by screw anchors or expansion bolts.

(c) Lavatories shall be so installed that the rims will be horizontal and without rocking, and the backhangers shall be accurately and firmly fastened. Installation shall be in accordance with the detailed drawings and fit in with the joints of ceramic tile finish.

(d) The locations of faucets and shower sets shall be determined by fit in with the joints of ceramic tile finish and for convenience of use, and shall be firmly installed without affecting the appearance. The edges of water discharge ends of faucets shall be sufficiently above the rims of fixtures to prevent back siphonage.

17. INSULATION

All hot water piping except exposed piping at fixtures shall be insulated with mineral fiber pipe insulation. Insulation thickness shall be 20 mm.

18. EXTERNAL SANITARY SEWER AND DRAINAGE SYSTEM

18.1 Locations and elevations

The Contractor shall follow the indicated locations and elevations as closely as possible, ground conditions permitting, and determine exact locations and elevations at site subject for approval.

The sewer shall not be closer horizontally than 2 m to a water-supply main or service line, except that where the bottom of the water pipe will be at least 300 mm above the top of the sewer pipe, the horizontal spacing may be a minimum of 1 m.

18.2 Minimum cover

Unless otherwise indicated or directed, maintain 300 mm minimum cover above piping.

18.3 Bedding

The bedding surface for the pipe shall provide a firm foundation of uniform density throughout the entire length of the pipe. The pipe shall be carefully bedded in a soil foundation that has been accurately shaped and rounded to conform to the lowest one-fourth of the outside portion of circular pipe. When necessary, the bedding shall be tamped. Bell holes and depressions for joints shall be only of such length, depth, and width as required for properly making the particular type joint.

18.4 Placing pipe

Each pipe shall be carefully examined before being laid, and defective or damaged pipe shall not be used. Pipelines shall be laid to the grades and alignment indicated. Proper facilities shall be provided for lowering sections of pipe into trenches. Pipe laying shall proceed upgrade with the spigot ends of bell-and-spigot pipe and tongue ends of tongue-and-groove pipe pointing in the direction of the flow. Each pipe shall be laid true to line and grade and in such manner as to form a close concentric joint with the adjoining pipe and to prevent sudden offsets of the flow line. Under no circumstances shall pipe be laid in water, and no pipe shall be laid when trench conditions or weather are unsuitable for such work. Diversion of drainage or dewatering of trenches during construction shall be provided as necessary. All pipe in place shall have been inspected before backfilling.

18.5 Infiltration and exfiltration

Leakage shall not exceed a rate of 0.06 litre per hour per 100 linear metre for any section between successive manholes. If infiltration appears excessive, the amount of leakage shall be measured by a suitable weir or other device as directed. When determination of infiltration is not practicable because of dry trench conditions, exfiltration tests shall be made if, as, and where directed. The tests shall be made by filling the sewer between successive manholes with water to the top of the outlet of the upper manhole. The amount of water required to maintain the pipe full for the required test period shall be measured and the rate of leakage determined. When leakage exceeds the maximum amount specified, satisfactory correction shall be made. Both measurement and correction shall be made at no additional cost.

18.6 Backfilling pipe

After the bedding has been prepared and the pipe installed, selected material from excavation or borrow, at a moisture content that will facilitate compaction, shall be placed along both sides of the pipe in layers not exceeding 150 mm in compacted depth. The backfill shall be brought up evenly on both sides of the pipe for the full length of the pipe. Care shall be taken to insure thorough compaction of the fill under the haunches of the pipe. Each layer shall be thoroughly compacted with mechanical tampers or rammers. This method of filling and compacting shall continue until the fill has reached on elevation of at least 300 mm above the top of the pipe. The remainder of the trench shall be backfilled and compacted by spreading and rolling, or compacted by mechanical rammers or tampers in layers not exceeding 300 mm and shall be compacted 90 per cent of maximum density. Where it is necessary, any sheeting and/or portions of bracing used shall be left in place.

18.7 Movement of construction machinery

In compacting by rolling or operating heavy equipment parallel with the pipe, displacement of or injury to the pipe shall be avoided. Movement of construction machinery over pipes at any stage shall be repaired or replaced at the expense of the Contractor.

18.8 Manholes

(a) General

Manholes shall be constructed of brick, concrete, precast concrete rings, or precast concrete segmental blocks, with cast iron covers, and in accordance with the drawings. The invert channels shall be smooth and semicircular in shape conforming to the inside of the adjacent sewer section. Changes in direction of flow shall be made with a smooth curve of as large a radius as the size of the manhole will permit. Changes in size and grade of the channels shall be formed directly in the concrete of the manhole base, or shall be built up with brick and mortar, or shall be half tile laid in concrete, or shall be constructed by laying full-section sewer pipe through the manhole and breaking out the top half after the surrounding concrete has hardened. The floor of the manhole outside the channels shall be smooth and shall slope toward the channels not less than 25 mm per metre nor more than 150 mm per metre. Free drop inside the manholes shall not exceed 450 mm measured from the invert of the inlet pipe to the top of the floor of the manhole outside the channels, and drop manholes shall be constructed whenever the free drop would otherwise be greater than 450 mm. When the depth from top of cover to invert of main sewer exceeds 3.5 m, manholes shall be provided with a straight-type steel ladder not less than 400 mm in width with 20 mm-diametre rungs spaced 300 mm apart. The ladder shall be adequately

anchored to the wall by means of steel inserts spaced not more than 1.5 m apart vertically and shall be so installed as to provide at least 150 mm of toe space between the wall and the inside of the rungs. The ladder and inserts shall be galvanized after fabrication. The wall along the line of the ladder shall be vertical its entire height. Ladders shall not be installed unless the depth exceeds 3.5 m.

(b) Concrete used in manholes shall have a compressive strength of not less than 210 Kg/cm^2 (3,000 p.s.i.) after 28 days.

(c) Jointing and plasting

Mortar for jointing and plastering shall consist of 1 part portland cement and 2 parts fine sand. For brickwork, lime may be added to the mortar in the amount of not more than 25 per cent of the volume of cement. The joints shall be completely filled and shall be smooth and free from surplus mortar on the inside of the manhole. Brick manholes shall be plastered with 15 mm of mortar over the entire outside surface of the walls.

(d) Frames and covers

Cast iron frames and covers shall conform to the drawings in all essentials of design. Approved standard coasting differing in nonessential details will be acceptable. The frames and covers shall have a combined weight of not less than 140 Kg (400 pounds). The letter "S", at least 50 mm high, shall be stamped or cast into all covers so as to be plainly visible. The frames and covers shall be so set that the top of the cover will be flush with or higher than finished grade as directed.

19. SEPTIC TANK AND SOAK AWAY

19.1 General

Septic tank and Soak away shall be constructed in the position and to the dimension shown on the drawings.

19.2 Septic tank shall have a capacity and shall be constructed of unsaturated polyester reinforced with glass fibre (FRP) as shown on the drawings. Septic tanks shall be mounted on the concrete pads. Concrete pads shall be so constructed that tanks are anchored stable to the pads and, when tanks are empty, they are stable against buoyant force caused by ground water. Concrete work shall be executed in comformity with the specification indicated in Section: CONCRETE WORK. During installation care shall be taken for dewatering of ground water.

19.3 Soak away shall have a capacity and shall be constructed in accordance with the applicable requirements hereinbefore specified for manholes.

19.4 Installation

Prior to installation of septic tank and soak way, detailed drawings shall be submitted to the Engineer for approval showing exact location of septic tank and the location of inlet sewer pipe.

20. INSPECTION, TEST, AND STERILIZATION

20.1 Tests for plumbing systems

Soil, waste, vent, and water piping shall be tested by the contractor and approved before acceptance. Underground soil and waste piping shall be tested before backfilling. Equipment required for test shall be furnished by the contractor.

20.2 Drainage and venting system piping shall be tested with water before the fixtures are installed. The water shall be kept in the system for at least 15 minutes before the inspection starts; the system shall then be tight at all joints.

20.3 Water system

When the roughing-in is completed and before fixtures are set, the entire potable and sea-water piping systems shall be tested at a hydrostatic pressure of not less than 7 kg/cm^2 gage, and proved tight at this pressure for not less tnan 30 minutes in order to permit inspection of all joints. Where a portion of the water-piping system is to be concealed before completion, this portion shall be tested separately as specified for the entire system.

20.4 Defective work

If inspection or test shows defects, such defective work or material shall be replaced or repared as necessary and inspection and tests repeated. Repairs to piping shall be made with new materials. No calking of screwed joints or holes will be acceptable.

20.5 Cleaning and adjusting

Equipment, pipes, valves, fittings, and fixtures shall be cleaned of grease, metal cuttings, and sludge that may have accumulated from operation of the system during the test. Any stoppage, discoloration, or other damage to the finish, furnishings, or parts of the building due to the contractor's failure to properly clean the piping system, shall be repaired by the Contractor. When the work is complete, the potable and sea water system shall be adjusted. Flush valves and automatic control devices shall be adjusted for proper operation.

20.6 Sterilization

After pressure tests have been made, the entire potable water distribution system to be sterilized shall be thoroughly flushed with water until all entrained dirt and mud have been removed before introducing chlorinating material. The chlorinating material shall be either liquid chlorine or hypochlorite. The chlorinating material shall provide a dosage of not less than 50 parts per million and shall be introduced into the system in an approved manner. The treated water shall be retained in the pipe

long enough to destroy all non-sporeforming bacteria. The retention time shall be at least 24 hours and shall produce not less than 10 p.p.m. of chlorine at the extreme end of the system at the end of the retention period. All valves in the system being sterilized shall be opened and closed several times during the contact period. The system shall then be flushed with clean water until the residual chlorine is reduced to less than 0.2 p.p.m. During the flushing period all valves and faucets shall be opened and closed several times.

SECTION 14C

AIR CONDITIONING AND VENTILATION

1. AIR CONDITIONING EQUIPMENT

All air conditioning equipment shall be designed to operate without malfunction upto maximum ambient condition of 50°C. All equipment installed externally or which can be affected by external conditions shall be capable of withstanding the effects of solar radiation, rain, wind, dust, sandstorm, salt or other weather phenomena prevalent in the area in which the building is located without damage or deterioration.

1.1 Air-cooled remote condenser type packaged air conditioners shall consist of indoor packaged air conditioner and outdoor air-cooled remote condenser. Unit shall be complete factory-fabricated and assemble unit. The following manufacturer's standard products may be approved by the Engineer on an "or approved equal" basis.

Hitachi Ltd.
6-2 Otemachi 2-chome
Chiyoda-ku, Tokyo, Japan

Telex: J 22395 HITACHY
International phone: +81·3·270·2111

Matsushita Electric Industrial Co., Ltd. (NATIONAL)
1006 Kadoma-City, Osaka, Japan

Telex: J 63426 MATUSITA
International phone: +81·6·908·1121

(a) Indoor packaged air conditioner shall consist of direct expansion coil, compressor, fan/motor, air filters, drain tray, integral thermostatic control, and unit casing.

(a-1) Compressor shall be of the hermetically sealed reciprocating type for use with R-22 refrigerant. Compressors shall have integrally cast housing of close-grained iron with oil-level bull's-eye, cast cylinder heads, cast-aluminum or forged-steel connecting rods, and cast iron or forged-steel crankshaft. Main bearings shall be sleeve-insert type, Lubrication system shall be of the forced-feed positive-displacement type with oil strainer. Shaft seal in open type units shall be mechanical type. Suction and discharge valves shall be flange connected, wrench operated, rising stem, with cap. Rotating parts shall be statically and dynamically balanced at the factory to eliminate vibration. Crankcase oil heaters shall be provided when the compressor will be subjected to ambient temperature

lower than the crankcase operating temperature. Oil heaters shall be provided and controlled as recommended by the manufacturer. Piston speed shall not exceed the manufacturer's recommendation.

(a-2) Drive shall be by an electric motor at speed that is not in excess of the speed for which the compressor is designed. Motors shall be induction type with continuous-duty rating, low-starting-current. Motors shall have totally enclosed enclosure. Motor starters shall be reduced-voltage type with weather-resistant enclosure. Motor shall be thermally protected against overheating, and overload protection shall be provided on all three phases.

(a-3) Controls

Compressors shall be provided with automatic capacity controls actuated by either pressure or temperature to provide step capacity reductions and cylinder unloading at start up, low-oil-pressure cutout, high-and-low-pressure cutout, and suction, discharge, and oil-pressure gages. Pressure cutouts and gages shall be factory mounted on a gage board. High pressure cutout shall actuate a 100 mm (4 in.) diameter alarm bell. Transformer for bell circuit shall be provided if required.

(a-4) Base

The unit shall be mounted on an all-welded structural-steel or cast iron base complete with vibration isolators with published load rating. The entire unit shall be isolated from the building structure.

(a-5) Direct expansion coils shall be fin-and-tube type constructed of seamless copper tubes and copper or aluminium fins mechanically bonded to tubes. Casing shall be not lighter than 16-gage (0.0653 inch in nominal thickness) galvanized steel with 14-gage (0.0806 inch in nominal thickness) flanges and support plates. Suction header shall be seamless copper tubing. Supply header shall consist of a distributor which shall distribute the refrigerant liquid through seamless copper tubing to all circuits in the coil equally. Tubes shall be circuited to insure minimum pressure drop and maximum heat transfer. Circuiting shall provide downward flow from liquid inlet to suction outlet. Each coil shall be tested at the factory under water at not less than 20.9 Kg/cm^2 (300 p.s.i.) air pressure and shall be suitable for 17.5 Kg/cm^2 (250 p.s.i.) working pressure. Each coil shall be completely dehydrated and sealed at the factory upon completion of pressure tests. Coils shall be mounted for counterflow service.

(a-6) Fans shall be double-inlet centrifugal type with each fan in a separate scroll. Fans shall be statically and dynamically balanced at the factory after fan assembly. Fans shall be mounted on steel shaft, ground and polished, and supported in ball-type bearings provided with lubrication facilities outside of the unit or permanently lubricated sleeve- or ball-type bearings. Fans and scrolls shall be furnished with an approved rust-inhibitor treatment. Fan shall be belt driven or direct connected to electric motor. Belt drives shall be designed for not less than 150 percent of the connected motor capacity, and sheaves shall be adjustable to provide not less than 20 percent speed variation. Sheaves shall be selected to drive the fans at such speed as to produce the specified capacity when set at the approximate midpoint of fan capacity. Fan motors shall have totally enclosed enclosures. Motors shall be induction type with continuous-duty rating, low-starting-current. Motor starters shall be magnetic across-the-line or reduced-voltage start type with general purpose enclosre. Fan tip speed and outlet velocity shall not exceed the recommendations of ASHRAE Guide and Data Books. A fire safety switch shall be provided in the return duct to de-energize the fan if the air temperature exceeds 60 deg. C. (140 deg. F.).

(a-7) Casing shall be constructed of not lighter than 16-gage (0.0653 inch in nominal thickness) steel treated inside with rust inhibitor. Drain pans shall be of not lighter than 12-gage (0.1112 inch in nominal thickness) steel, waterproofed by coating with a noncombustible water-proofing material. Casing and drain pan shall be insulated at the factory, acoustically and thermally, and internally with not less than 12.5 mm (1/2 in.) thick semirigid fibrous-glass insulation material. Access doors or removable panels shall be provided in each casing section. Casing of units exposed to the weather shall be 14-gage (0.0806 inch in nominal thickness) steel weatherproofed and insulated internally with 40 mm (1-1/2 inch) thick semirigid fibrous-glass insulation.

(a-8) Cleanable air filter shall be installed to return air pass through the direct expansion coil.

(b) Air-cooled remote condenser shall be mounted in a weather-protected casing and shall be a complete factory - fabricated and - assembled unit consisting of coils, fans, and electric motor drive. The air-cooled condenser capacity rating shall be based on 45°C dry bulb entering outside air temperature. The condenser shall be capable of maintaining continuous operation of the refrigeration compressor when the outside entering air is -12°C above design ambient air temperature specified above. Air discharge grilles shall be provided with wire mesh bird screens.

(b-1) Condenser shall be of the extended-surface fin-and-tube type and shall be constructed of seamless copper or aluminium tubes with copper or aluminium fins. The fins shall be soldered or mechanically bonded to the tubes and installed in a metal casing. The coil shall be designed and tested after assembly. After testing, the coil shall be dried to remove free moisture and capped to prevent entrance of foreign matters.

(b-2) Fans shall be either centrifugal or propeller driven as best suited for the application. Fans shall be belt driven or direct connected to electric motors. Belt drives shall be completely enclosed within the unit casing or provided with a guard and an adjustable sheave to provide not less than 20 percent fan-speed adjustment.

(b-3) Electric motor shall be totally enclosed. Motor starter shall be magnetic across-the-line type with weather-resistant enclosure.

1.2 Direct expansion fan coil units shall consist of indoor fan coil unit, outdoor air-cooled condensing unit and thermostat with on-off switch shall be a complete factory-fabricated and - assembled unit. The following manufacturer's standard products may be approved by the Engineer on an "or approved equal" basis.

Matsushita Electric Industrial Co., Ltd. (Japan)
" NATIONAL "

Carrier Co. (U.S.A.)

(a) Fan coil unit shall consist of direct expansion coil, fan/motor, cleanable air filter, and unit cabinet. All items shall be in accordance with Paragraph: Air-cooled remote condenser packaged air conditioner.

(b) Air-cooled condensing unit shall consist of compressor, condenser coil, fans/motors, and weather-protected unit casing. All items shall be in accordance with Paragraph: Air-cooled remote condenser packaged air conditioner.

1.3 Air-cooled self-contained air conditioning units shall be of a one-piece air to air cooling unit consist of direct-expansion coil, compressors, condenser coil, filters, indoor and outdoor fans, safety controls, automatic controls, thermostat assembly, and unit cabinet. Unit shall be complete factory - fabricated and assemble unit. Air-cooled self-contained air conditioning unit shall be of the product of "Carrier Co." or approved equal.

(a) Compressor shall be in accordance with Paragraph: Air-cooled condensing unit.

(b) Drive shall be in accordance with Paragraph: Air-cooled condensing unit.

(c) Controls shall be in accordance with Paragraph: Air-cooled condensing unit.

(d) Base shall be in accordance with Paragraph: Air-cooled condensing unit.

(e) Air-cooled condenser shall be in accordance with Paragraph: Air-cooled condensing unit.

(f) Direct expansion coil shall be in accordance with Paragraph: Direct expansion fan-coil units.

(g) Indoor fan shall be of the forward-curved centrifugal class 1 type, belt driven by a motor. Other items shall be in accordance with Paragraph: Direct expansion fan-coil units.

(h) Outdoor-fans shall be of the propeller type, each directly driven by a inherently protected motor. Other items shall be in accordance with Paragraph: Direct expansion fan-coil units.

(i) Thermostat assembly shall consist of thermostat, manual or automatic changeover switch and continuous or automatic fan operation swtich.

(j) Unit cabinet shall be constructed of galvanneal steel, bonderized and coated with baked enamel. Other items shall be in accordance with Paragraph: Direct expansion fan-coil units.

(k) Cleanable filter shall be installed to return air pass through the direct expansion coil.

1.4 Room air conditioning units shall be of the "through-the-wall" type, consist of a permanent cleanable filter, permanently lubricated fan, integral thermostatic control, 4-way adjustable grilles, hermetically sealed resiliently mounted compressor motor, fully sealed refrigerant charge, evaporator and air cooled condenser coils, internal insulation, insulated drain tray and unit casing. Unit casing shall be built of heavy gauge sheet steel, zinc coated, phosphatized, and covered with an extruded thermosetting plastic finish applied after the sheet metal is formed.

2. VENTILATION EQUIPMENT

2.1 Wall exhaust fans shall be the propeller type, wall mounted, direct motor driven type. Fan motor shall be totally enclosed with double sealed, permanently lubricated ball bearings. Fan blades and casing shall be constructed of heat-proof plastics or baked enamel coated steel or anodized aluminium. Wall exhaust fan shall be provided back-draft shutter and aluminium or FRP weathering cover. Stainless steel nuts, bolts and washers shall be used for all fixings exposed to the weather.

2.2 Tubular fans shall consist of tubular casing and blades directly connected to the electric motor. Fans shall be connected to the ducts by flexible duct connection.

3. DUCTWORK

3.1 General

Ductwork shall be constructed of galvanized iron, galvanized steel sheets. Unless otherwise approved, ducts shall conform accurately to the dimensions indicated, and shall be straight and smooth on the inside, with joints neatly finished. Ducts shall be anchored securely to the building and shall be so constructed and installed as to be completely free from vibration under all conditions of operation. Curved elbows shall have a centerline radius not less than 1-1/2 times the width of the duct unless provided with turning vanes. Joints shall be made substantially airtight, and no dust marks from air leaks shall show at duct joints or connections to grilles, registers, and diffusers. Laps shall be made in the direction of airflow. Edgs and slips shall be hammered down to leave a smooth interior-duct finish. Button or bolt connections in standing seams shall be spaced at fixed centres not greater than 150 mm (6 in.) spacing. Transformations shall be made with a slope ratio of 5:1 minimum and 7:1 where practicable, or in a specifically approved manner. Duct construction, hangers, and anchors shall comply with details outlined in ASHRAE Guide and Data Books. Sheet metal gages and stiffeners shall be as follows:

Size of Duct	Gauge of Sheet Metal
300 mm (12") or less in width or depth	Gauge 26
301 to 750 mm (12" to 30") in width or depth	Gauge 24
751 to 1500 mm (30" to 60") in width or depth	Gauge 22
1501 mm (60") in width or depth	Gauge 20

3.2 Splitters and dampers

Dampers shall have accessible operating mechanism, and where operators occur in finished portions of the building, operators shall be chromium plated with all exposed edges rounded. Splitter dampers shall be operated by damper quadrant or by 4.7 mm (3/16 in.) rod, using two rods on splitters over 200 mm (8 in.) in height. Damper quadrant or rod shall be brought through the side of the duct with locking setscrews and bushing. Manual volume-control dampers shall be operated by locking-type quadrant operators. Dampers and splitters shall be 2 gages heavier than duct in which installed. Multi-leaf dampers shall be opposed-blade type with maximum blade width of 300 mm (12 in.). Splitter dampers shall be of sufficient length to close off either branch duct.

3.3 Air deflectors shall be provided in all square elbows, duct-mounted supply outlets, and tap-in branch-takeoff connections. Air deflectors shall be factory fabricated and assembled.

3.4 Fire dampers shall be provided in accordance with the National Fire protection Association Standard No.90A. Dampers shall be installed with sufficient tension to prevent rattling or vibration.

3.5 Duct access doors

Hinged access doors shall be provided at all automatic dampers, fire dampers, thermostats, and all other apparatus requiring service and inspection in the duct system. Access doors shall be 450 mm by 450 mm (18 by 18 in.) unless indicated. Where size of duct will not accommodate this size, access doors shall be made as large as practical. Access doors shall be provided on each side of each air-handling unit and shall not be less than 600 mm by 600 mm (24 by 24 in.). Access doors shall be of rigid type and shall be provided with felt gaskets to make doors air-tight. Doors shall be provided with galvanized hinges having bronze pins and two approved brass fasteners. All doors 600 mm by 600 mm (24 by 24 in.) or larger shall be provided with fastners that can be operated from both sides. Access doors in insulated ducts shall be of the insulated type. Doors shall swing so that fan pressure or suction holds the door closed, unless indicated.

3.6 Duct test holes

Holes with patches in ducts and plenums shall be provided where directed or necessary for using pivot tubes for taking air measurements to balance the air systems. At each of these locations where ducts or plenums are insulated, extension shall be provided with plug fittings.

3.7 Apparatus connections

At points where sheet-metal connections are made to air-handling units, a flexible connection of 0.43 Kg (15-ounce) woven asbestos, or other approved noncombustible material, approximately 200 mm (8 in.) in width shall be installed and securely fastened by zinc-coated iron clinch-type bands.

3.8 Duct sleeves shall be fabricated from 22-gage galvanized sheet steel unless indicated. Flanges constructed of 22-gage galvanized sheet steel not less than 100 mm (4 in.) wide shall be installed tight against the wall on each side of the wall and fastened to the sleeve. Duct insulation and vapour barrier shall extend through the duct sleeve. Sleeves shall be 50 mm (2 in.) larger than the duct unless required by the thickness of the insulation used. Framed openings shall be provided for ducts larger than 30 mm (12 in.) in diameter and for all square and rectangular ducts. The space between the duct or duct insulation and the opening or sleeve shall be packed with commercial-grade twisted asbestos rope.

3.9 Duct supports shall consist of not less than 25 mm (1 in.) by 2 mm (1/16 in.) galvanized strap-iron hangers spaced not over 1200 mm (4 ft.) on centres. Duct risers shall be supported at each floor.

4. DIFFUSERS, REGISTERS, GRILLES

4.1 General

Diffusers, registers, and grilles shall be factory-fabricated aluminium and shall distribute the quantity of air specified evenly over space intended without causing noticeable drafts over 0.25 m/sec (50 f.p.m.). The Contractor shall be responsible for diffusion, spread, drop, and throw. If, according to the certified data of the manufacturer of the proposed units, the sizes indicated will not perform satisfactorily, the units shall be reselected to perform quietly and effectively in accordance with the manufacturer's recommendations.
A schedule of all air inlets and outlets indicating location, specified air quantity, neck or face velocity, noise level, pressure drop, throw and drop for registers, and maximum and minimum diffusion range shall be submitted. Diffusers and registers shall be provided with volume control and accessible operator. After the system is in operation, if excessive noise, drafts, or dead spots, are noticeable in the conditioned spaces due to improper selection of type and size of diffuser, grille, or register, the unit shall be changed to the proper size and type without additional cost. The colour of the diffusers, registers, and grilles shall be indicated by Engineer.

4.2 Diffusers shall be round, half-round, square, rectangular, or strip shape as indicated, and shall be of the expanding-cone type, the plaque type, or a combination of the two types. Sponge-rubber gasket shall be provided between ceiling and diffuser or antismudge ring. Duct collar connecting the duct to diffuser shall fit inside of diffuser neck.

4.3 Registers shall be four-way directional-control type except that return and exhaust registers may be fixed pattern of design similar to supply-register face. Each register shall be provided with a face-operated opposed-blade volume-control damper. Registers shall be provided with sponge-rubber gasket between flange and wall or ceiling. Wall-supply registers shall be installed at least 150 mm (6 in.) below the ceiling. Return and exhaust registers shall be located 150 mm (6 in.) above the floor unless indicated. Free area of all registers shall be not less than 60 percent of face area.

4.4 Louvers in the air-conditioning system shall be either in building wall or directly connected by ductwork. Louvers shall be fabricated from aluminium sheets, and shall be provided with frames of aluminium structural shapes. Blades shall be accurately fitted and firmly secured. Edges of louver blades shall be folded or beaded for rigidity, and shall be baffled to exclude driving rain. Bird screen shall be provided where indicated on the drawings.

4.5 Grilles shall be as specified for registers, without volume-control dampers.

4.6 Sound insulation for Duct

Ductwork to be internally sound insulated are indicated on the drawings by hatching. Duct lining shall be 25 mm (1 in.) thick fiberglass with glass cloth and vinyl net covering to help prevent fiber erosion and reduce resistance to air flow. Lining shall be attached to ductwork by cementing. Where ducts are lined thus, the duct width and height shall be increased by lining thickness to match free air passage cross-sectional areas of lined and adjoining unlined metal cut.

5. REFRIGERANT PIPING

5.1 Pipe

Refrigerant piping shall be copper pipe or copper tubing. Copper tubing shall be type K or L, bright annealed, dehydrated, and sealed. Soft-temper tubing shall be used where bending is required, and where flare joints are used. Hard-drawn tubing shall be used where no bending is required and silver brazed joints are used. Copper-tube joints shall be brazed except that joints on lines 15.5 mm (5/8 in.) or smaller may be flared. Fittings for flare joints shall be standard SAE Forged-brass flare type with short-shank flare units. Fittings for brazed joints shall be wrough-copper or forged-brass sweat fittings. Cast sweat-type fittings will not be allowed for brazed joints.

5.2 Vibration isolators of the all-metallic bellows and woven-wire type shall be provided on suction and discharge lines where connections to compressor are made.

5.3 Refrigerant-service valves shall be designed for use with the refrigerant used and shall have pressure ratings compatible with system working pressures encountered. Gate valves will not be acceptable. Valves shall be all-brass packless-type globe valves, wrench operated with brass or steel sealcaps.

5.4 Check valves shall be brass body, lift or swing type suitable for refrigerant liquid or gas service as required.

5.5 Expansion valves shall be designed for use with the type of refrigerant used with a pressure rating suitable for pressures encountered. The valves shall be of the thermostatic type, diaphragm or bellows operated, with an adjustable external superheat adjustment set at the factory for -12 degree C. superheat. Power elements and valve size shall be as recommended by the valve manufacturer for the service intended.

5.6 Dehydrator shall consist of a steel cylinder filled with a suitable desiccant through which the refrigerant is passed. The desiccant shall be such that it will not plug, cake, dust, channel, or break down, and shall remove both water and acid from the refrigerant. The dryer shall be constructed so that none of the desiccant will pass into the refrigerant lines. The dryer pressure rating shall be suitable for the pressures encountered. A dehydrator shall be provided in the liquid line to each evaporator and shall be piped with a three-valve bypass.

5.7 Strainers shall be installed in the refrigerant line on the inlet side of each thermostatic expansion valve. Strainers may be an integral part of the expansion valve.

5.8 Sight glasses shall be glass, see-through type or bull's-eye type with cover cap. Sight glass shall be provided in liquid line immediately preceding each expansion valve and where indicated.

5.9 Discharge-line oil separator of rated capacity equal to or greater than the compressor capacity shall be provided in the discharge line from each compressor when recommended by the compressor manufacturer. The separator shall be provided with an oil-float valve assembly or needle valve and orifice assembly, drain-line shutoff valve, and sight glass. The oil-return line shall be connected to the compressor as recommended by the compressor manufacturer.

5.10 Installation

Pipe shall be cut accurately to measurement established at the jobsite and worked into place without springing or forcing. Cutting or other weakening of the building structure to facilitate piping installation will not be permitted. Pipes shall be cut square, shall have burs removed by reaming, and shall be so installed as to permit free expansion and contraction without damage to joints or hangers. Filings, dust, or dirt shall be wiped from interior of pipe before connections are made. Changes in direction shall be made with fittings, except that bending of pipe will be permitted, provided a hydraulic or mechanical pipe bender is used and wide-sweep bends are formed. Bent pipe showing kinks, wrinkles, or other malformations will not be accepted. All piping shall be installed with sufficient pitch to insure adequate oil drainage. Open ends of pipelines or equipment shall be properly capped or plugged during installation to keep moisture, or other foreign material out of the system. Copper-tubing joints shall be brazed with silver solder. Joints in lines not insulated shall be polished after cooling to remove all heat marks. Flanged joints shall be faced true, provided with not less than 1/16-inch-thick soft-lead gaskets and made square and tight. Union or flange joints shall be provided in each line immediately preceding the connection to each piece of equipment or material requiring maintenance such as compressors, coils, control valves, and other similar items. Valves in gas lines shall be installed with stems horizontal or above. Stop valves shall be installed on each side of each piece of equipment such as compressors, condensers, receivers, and other similar items and at any other points indicated or required for maintenance, isolation, charging, or sectionalizing purposes. Each valve, except check valves, shall be identified with not less than a 2-inch-diameter brass tag correctly stamped to explain the valve function and with a number for identification. Tags shall be secured to the valve with 18-gage copper or brass wire. Piping located under the concrete floor slab shall be installed in 150 mm diameter PVC piping and without joints where possible.

(a) Pipe supports

Piping shall be supported by adjustable hangers. Chain, wire, strap, or other makeshift devices will not be permitted as hangers or supports. Piping shall have a maximum support spacing of not over 40 pipe diameters. Valves in copper lines smaller than 1 inch shall be supported indenpendently of pipe. Brackets or clamps may be used where pipe runs along walls. Pipe hangers or brackets shall be properly isolated where necessary to prevent noise transmission. Where pipes are insulated, the size and position of the hanger shall be such as to bear on the outside of the insulation. Sleeves or saddles of no lighter than 18-gage (0.0530 inch in nominal thickness) galvanized steel shall be placed between hangers and insulation. Supports or hangers for uninsulated copper lines shall be copper coated.

(b) Pipe sleeves

Pipes passing through concrete or masonry walls or concrete floors or roofs shall be provided with pipe sleeves fitted into place at the time of construction. Sleeves shall not be installed in structural members except where indicated or approved. Each sleeve shall extend through its respective wall, floor, or roof, and shall be cut flush with each surface. Sleeves shall be of such size as to provide a minimum of 6.5 mm (1/4 in.) all around clearance between bare pipe and sleeves or between jacket over insulation and sleeves. Sleeves in bearing walls, waterproofing membrane floors, and wet areas shall be steel pipe or cast iron pipe. Sleeves in non-bearing walls, floors, or ceilings may be steel pipe, cast iron pipe, or galvanized sheet metal with lock-type longitudinal seam. Except in pipe chases or internal walls, the annular space between pipe and sleeve or between jacket over insulation and sleeve shall be sealed. Metal jackets shall be provided over insulation passing through external walls, fire walls, fire partitions, floors, or roofs, and shall not be less than 0.4 mm (0.06 in.) thick aluminium and shall be secured with aluminium or stainless-steel bands not less than 10 mm (3/8 in.) wide and not more than 200 mm (8 in.) apart. Where penetrating roofs, before fitting the metal jacket into place, a 12.5 mm (1/2 in.) wide strip of sealant shall be run vertically along the inside of the longitudinal joint of the metal jacket from a point below the backup material to a minimum of 900 mm (36 in.) above the roof. If the pipe turns from vertical to horizontal, the sealant strip shall be run to a point just beyond the first elbow. When penetrating waterproofing membrane for floors, the metal jacket shall extend from a point below the backup material to a minimum of 50 mm (2 in.) above the flashing sleeve. For other areas, the metal jacket shall extend from a point below the backup material to a point 300 mm (12 in.) above the floor, or when passing through walls shall extend a minimum of 10 mm (4 in.) on either side of the wall.

(c) Pipes passing through waterproofing membranes

Pipes passing through roof or floor waterproofing membrane shall be installed through a 1.8 Kg (4 pound) lead-flashing sleeve, a 0.45 Kg (16 ounce) copper sleeve, or a 0.81 mm (0.032 in.) thick aluminium sleeve, each within an integral skirt or flange. Flashing sleeve shall be suitably formed, and the skirt or flange shall extend not less than 203 mm (8 in.) from the pipe and shall set over the roof or floor membrane in a troweled coating of bituminous cement. The flashing sleeve shall extend up the pipe a minimum of 50 mm (2 in.) above the highest flood level of the roof or a minimum of 254 mm (10 in.) above the roof, whichever is greater, or 254 mm (10 in.) above the floor. The annular space between the flashing sleeve and the bare pipe or between the flashing sleeve and the metal-jacket-covered insulation shall be sealed.

(d) Floor, wall, and ceiling escutcheons

Escutcheons shall be provided at all finished surface where exposing piping, bare or insulated, passes through floors, wall, or ceilings. Escutcheons shall be fastened securely to pipe or pipe covering and shall be chromium-plated iron or chromium-plated brass, either or split pattern, held in place by internal spring tension or setscrew.

5.11 Refrigerant pipes and fittings shall be of a type and size recommended by the air-conditioning equipment manufacturer and the Contractor shall submit for approval.

6. INSULATION

6.1 Duct insulation

(a) General

Ducts shall be insulated to the thickness with mineral wool or cellular glass. Insulation shall be of the flexible type for concealed ducts and the rigid or semirigid type for exposed ducts. A vapour-barrier facing material consisting of 0.05 mm (0.002 in.) thick aluminium foil reinforced with kraft paper and glass fibers or other approved vapour-barrier material, shall be applied to the exterior of all duct insulation. Vapour-barrier shall be noncombustible. Insulation shall be secured to rectangular ducts by welded pins or metal stick clips and speed washers spaced not over 300 mm (12 in.) on centres each way, by 18-gage copper-clad-steel wire spaced not over 450 mm (18 in.) on centres, or by a combination of the two methods if necessary to accomplish a neat finished installation. In all cases where insulation joints occur, facing tabs shall be overlapped not less than 50 mm (2 in.) and sealed with an approved noncombustible adhesive recommended by manufacturer of the facing material. All punctures in the facing material shall be sealed.

(b) Thickness of material

(b-1) Return-air ducts, and air-conditioning supply ducts outside of the conditioned area: 25 mm (one-inch-thick) material.

(b-2) Insulated ducts exposed in equipment rooms or other locations subject to damage shall be insulated and vapour sealed, covered with chicken wire, and finished with 12 mm (1/2 in.) thick smooth trowel coat of Keene's cement.

(b-3) Insulated ducts exposed to weather

Two-inch-thick material. Insulation finish shall be 0.41 mm (0.016 in.) thick corrugated-aluminium sheet with joints lapped not less than 75 mm (3 in.), sealed and secured with No.6 by 10 mm (3/8 in.) aluminium sheet-metal screws, or aluminium hand-gun-type rivets.

6.2 Pipe Insulation

(a) General

No pipes shall be insulated until after tests are complete. Refrigerant suction lines, shall be insulated with foam polystyrene pipe insulation. Insulation shall be jacketed with nonadhesive not less than 0.2 mm thick vinyl tapes. Lap of jacketing material shall be not less than 15 mm. Adhesive tape shall be used to protect vinyl tape from slipping. Fittings and valves shall be covered with the same material of the same thickness and jacketing as the pipe insulation and sealed with an approved vapour-sealing tape and a hard smooth surface of approved insulating cement. Covering shall be finished neatly at pipe hangers and shall be terminated neatly on the ends of the unions with approved insulating cement.

(b) Thickness of material

Insulation thickness of refrigerant pipes shall be not less than 30 mm.

(c) Pipe insulation exposed to weather shall be provided with an additional jacket consisting of 0.15 mm (0.006 in.) thick corrugated-aluminium sheet with 50 mm (2 in.) lap connected with 25 mm (1 in.) hem overlap joint located on side of pipe and turned down to shed water. Jacket shall be strapped 300 mm (12 in.) on centres with 10 mm (3/8 in.) wide aluminium, lock-type straps. Factory-applied jackets, consisting of 0.4 mm (0.016 in.) thick flat aluminium and vapour-sealing type aluminium bands, may be provided in liue of the corrugated jacket at the option of the Contractor. Aluminium jacket material shall be mitered to fit all fittings.

(d) Acoustical duct lining shall not be less than 25 mm (1 in.) thick, 3-pound-per-cubic-foot-density fibrous glass with a noncombustible coating on the surface in contact with the air. The duct-lining material shall be non-combustible. Noise-reduction coefficient shall be not less than 0.60. The lining shall be applied in cut-to-size pieces fastened to the interior of the duct with approved noncombustible adhesive. Duct panels over 24 inches wide shall have the lining additionally secured with sheet-metal screws and washers.

7. EQUIPMENT INSTALLATION

Necessary supports shall be provided for equipment, appurtenances, pipe, and ductwork as required. All floor-mounted equipment shall be set on not less than 150 mm (6 in.) concrete pad doweled in place. Foundation drawings, bolt-setting information, and foundation bolts shall be submitted for approval for all equipment indicated or required to have concrete foundations.

8. ACCESS PANELS

Access panels shall be provided for all concealed valve controls, dampers, or any item requiring inspection or maintenance. Access panels shall be of sufficient size and so located that the concealed items may be serviced and maintained or completely removed for replacement.

9. CLEANING, TESTING, AND BALANCING

9.1 Cleaning and adjusting

Pipes shall be cleaned free of scale and thoroughly flushed of all foreign matters. Strainers and valves shall be thoroughly cleaned. Ducts, plenums, and casing shall be thoroughly cleaned of all debris and blown free of all small particles of rubbish and dust before installing outlet faces. Equipment shall be wiped clean, with all traces of oil, dust, dirt, or paint spots removed. Temporary filters shall be provided for all fans that are operated during construction, and after all construction dirt has been removed from the building, new filters shall be installed. Bearings shall be properly lubricated with oil or greases as recommended by the manufacturer. Belts shall be tightened to proper tension. All control valves and other miscellaneous equipment requiring adjustment shall be adjusted to setting indicated or directed. Fans shall be adjusted to the speed indicated by the manufacturer to meet specified conditions.

9.2 Testing

(a) Refrigerant piping connecting condensers and cooling coils shall be subjected to a pneumatic test. The pneumatic testing shall be done with anhydrous carbon dioxide or dry nitrogen before any refrigerant pipe is covered. The high and low side of the refrigerant system shall be tested for the minimum refrigerant-leak filed-test pressure specified in American Standards Association Standard B9.1 for the refrigerant employed in the system. The system shall be proved tight under test pressure by first checking each joint with soap solution and second, with a halide torch or by electronic leak detection. Leaks detected shall be repaired by taking the joint apart, thoroughly cleaning, and remarking as a new joint. Joints repaired by calking

or remelting and adding more brazing material will not be acceptable. The system will be proved tight and free of leaks by successfully completing the soap and detector tests and by allowing the leak-test pressure to remain on the system for 24 hours with no drop in pressure. Correction of 0.3 pound per square inch will be allowed for each degree change in the initial and final temperature of the surrounding air, plus for an increase and minus for a decrease. After the above-mentioned tests have been satisfactorily completed and the pressure relieved, the entire system shall be evacuated to an absolute pressure of 5,000 microns (0.2 inch of Hg) or less at ambient room temperature of not less than 12.8 deg. C (55 deg. F.). The vacuum line shall be closed, and the system shall stand for 2 hours. After this period the increase in absolute pressure shall not exceed 25 microns. During this test, pressure shall be recorded using a thermocouple-type, electronic-type, or a calibrated micron gage. Upon completion of the test, the vacuum shall be broken by charging the system with dry refrigerant for which the system is designed.

(b) Ductwork

Ducts, plenums, and casings shall be tested and made substantially airtight at static pressure indicated for the system before covering with insulation or concealing. Substantially airtight shall be construed to mean that no air leakage is noticeable through the senses of feeling or hearing.

(c) Balancing

Duct systems shall be balanced to produce air quantities within 5 percent of that indicated.

9.3 Performance tests

After cleaning, balancing, and testing operations have been completed, the system shall be tested as a whole to see that all items perform as an integral part of the system, and that temperatures and conditions are evenly controlled throughout the building. Corrections and adjustments shall be made as necessary to produce the conditions indicated.

9.4 Lubricating oil

Two complete charges of lubricating oil for each compressor crankcase shall be furnished. The oil shall be of a type recommended by the manufacturer of the equipment. One charge shall be used during the performance testing period, and upon the satisfactory completion of the tests, the oil shall be drained and replaced with the second charge.

SECTION 14D

SEA WATER SERVICE SYSTEM

1. GENERAL

Sea water service system shall consist of sea water pumps, settling tank, header tanks, fitting equipment and distribution piping. All materials to be used for sea water service shall have excellent chemical resisting characteristics to sea water. Sea water service system is divided into two subsystem as follows:

a) Filtered sea water service system
b) Raw sea water service system

2. SEA WATER FILTERING EQUIPMENT

Sea water shall be filtered by full automatic gravity type sand filter and capacity and sizes as shown on the drawings. The raw sea water shall be supplied from the header tank by gravity. The inlet raw sea water is distributed uniformly from the flow weir to all unit of the filter where it is removed of turbidities by filter media. The filtered sea water is collected by the underdrain and flows out of the outlet weir and being led to the filtered sea water reservoir. The operation for backwash is automatically according to the time setting of filtration. Sea water filtering equipment shall consist of reinforced concrete tank, filter media, surface wash system, underdrain system, waste water discharge troughs, waste water discharge siphon pipes. Inlet weirs, filtered water outflow weirs, surface wash pump, ejectors, motorised pvc valves, oriflow meters, electrode and control system.

2.1 Filter media shall be as follows:

(1) Marble stone: 1 - 2 mm diametre, 50 mm depth
(2) Filter sand: 0.6 mm diametre (effective size)
550 mm depth
uniformity coefficient 1.4 or less
(3) Supporting gravel:

effective size:	depth:
2 - 4 mm	50 mm
4 - 8 mm	50 mm
8 - 12 mm	50 mm
12 - 20 mm	50 mm

2.2 Surface wash system

Six (6) sets of surface wash system shall be provided and each system shall consist of 65 and 40 mm diametre polyvinyl chloride (PVC) pipe 8 pcs. nozzles.

2.3 Under drain system

Six (6) sets of under drain system shall be provided and each system shall consist of 8 pcs. of pre-stress concrete plates (600 mm square) with I-type strainers, made of polypropylene.

2.4 Waste water discharge trough

Six (6) sets of waste water discharge trough shall be provided. Discharge trough shall be of fiber-glass reinforced plastic (FRP) and sizes shall be as follows:

Width : 300 mm Length : 2,600 mm Depth : 250 mm

2.5 Waste water discharge siphon pipe

Six (6) sets of waste water discharge siphon pipe shall be provided and shall be 200 mm diametre FRP reinforced PVC pipe with a nozzle for vacuum.

2.6 Inlet weir

Six (6) sets of inlet weir shall be provided and shall be of PVC plate with frame. Sizes shall be as follows:

Width : 100 mm Length : 400 mm

2.7 Filtered water outflow wier shall be 5 pcs. 100 mm wide 1,200 mm long and made of wood with frame.

2.8 Surface wash pump shall be of the horizontal, centrifugal type and shall be direct-connected to the electric motor through flexible couplings. The pump shall be designed for sea water works service. Pump casing, impeller, shaft, and shaft sleeve shall be of stainless steel. Other items shall be in accordance with paragraph - Water Pumps.

2.9 Ejectors shall be provided to produce siphonage and shall be of cast iron with rubber lined

Sea water filtering equipment shall be similar or equal to "EBARA-INFILCO CO., LTD.". (Palace side Bldg., 1-1, Hitotsubashi, Chiyoda-ku, Tokyo, Japan, Telex: J 22441 EBAFILCO, International Phone: +81.3.212.3311).

3. SEA WATER SERVICE PIPE, FITTING AND CONNECTIONS

3.1 Sea water service pipe shall be polyvinyl-chloride water pipe comforming to BS 3505 and 3506 or equivalent international standards.

3.2 Fitting shall be compatible with the pipe material.

3.3 Installation of pipes and fittings shall conform to Paragraph: Plumbing. Joints for polyvinyl-chloride pipe and fittings shall be made using solvent cement and free from uneven surfaces at inside of the pipe affecting water flow.

3.4 Valves installed for sea water service system shall be all polyvinyl-chloride light chemical type. Valves up to and including 50 mm shall be ball valve with flange ends. Valves from 65 mm up to and including 200 mm shall be gate valve with flange ends, 250 mm and larger shall be butterfly valve with flange ends. Valves shall be similar or equal to "ASAHI YUKIZAI KOGYO CO., LTD." (Gojokai Bldg., 15-9 Uchi-Kanda 2-chome, Chiyoda-ku, Tokyo, Japan, Telex: J 222-2134 AYKPOK, International Phone: +81.3.254.7221) of type and size as shown on the drawings.

4. HEADER TANK

Header tank shall be constructed of unsturated polyester reinforced with glass fibre (FRP) prefabricated panel as shown on the drawings and shall conform to Paragraph: Plumbing.

5. SEA WATER PUMP

Sea water pumps shall be of the horizontal, centrifugal type and shall be direct-connected to the electric motor through flexible couplings. The pump shall be designed for sea water works service. Pump casing, impeller, shaft, and shaft sleeve shall be of stainless steel. Other items shall be in accordance with Paragraph: Water Pumps.

SECTION 14E

AIR DISTRIBUTION SYSTEM

1. GENERAL

Air distribution system shall be provided for aeration of sea water tanks and ponds. Air shall be supplied by means of rotary blowers through air distribution piping to each tanks and ponds.

2. ROTARY BLOWER

Rotary blowers shall be of dry compression service type and shall be statically and dynamically balanced at the factory. Rotary blowers shall be driven by a unit mounted motor connected to blowers by V-belt drive complete with belt guard. Motors shall be totally enclosed. Rotating parts shall be labyrinth-sealed non-contact type. Bearings shall be protected from hot blast by means of flinger. Lubricating oil shall be protected by air-cooling and water-cooling fins. The interior of the casing shall be oil-free type. Lubrication system shall be splash lubrication type for gear side and oil bath luburication type for driving side. Casing, cover and rotor shall be of cast-iron, and shaft shall be carbon steel. Rotary blower and electric motor shall be mounted on a common base arranged for bolting to a concrete foundation.

2.1 Accessories shall be as follows (for each rotary blower):

Common base	1 ea
Suction filter	1 ea
Suction silencer	1 ea
Discharge silencer	1 ea
Safety valve	1 ea
Vacuum breaking valve	1 ea
Check valve	1 ea
Sluice valve	1 ea
Pressure gauge	1 ea
Vacuum gauge	1 ea
Compound pressure gauge	1 ea
Thermometer	1 ea
Flexible joint	2 ea
Vibration absorber (rubber)	4 ea
Disassembly tools	1 set

2.2 Foundation shall conform to Paragraph: Pump Foundation.

3. AIR DISTRIBUTION PIPE

Air distribution pipes shall be polyvinyl-chloride (PVC) water pipe comforming to BS 3505 and 3506 or equivalent international standards. Fittings shall be compatible with the pipe material.

4. VALVE

Valves installed for air distribution system shall conform to Section: SEA WATER SERVICE SYSTEM.

5. PIPE INSTALLATION AND OTHER ITEMS

Pipe installation and other items shall conform to Section: SEA WATER SERVICE SYSTEM and PLUMBING.

SECTION 14F

WALK-IN FREEZER

1. GENERAL

Walk-in freezer shall be of a factory-made pre-fabricated, sectional version of the built-in freezer, consist of low heat-conductivity sectional pre-fabricated panels, base frame, skid, air-cooled condensing unit, direct expansion fan coil unit, thermometer and compartment lamp. All parts of the walk-in freezer shall be shipped to the site and elected on the Job. Walk-in-freezer shall be similar or equal to "SANYO MURAKO INT. CO., LTD." (8-6 Kameido 1-chome, Koto-ku, Tokyo, Japan, Telex: J 26222185 SMI, International Phone: +31.3.684.6861).

2. FREEZER COMPARTMENT

Freezer compartment shall consist of ceiling panels, siding panels, corner panels, floor panels, door panels with magnetic double gaskets door, skids and base frame.

2.1 Pre-fabricated panels shall be filled with foamed-in-place polyurethane insulation and the two surfaces of the panels shall be covered with high-grade steel sheet, galvanized electrostatically, and polyvinyl chloride (PVC) coating. Panels shall have double gaskets and dipense with the post-assembly caulking of the panel seam.

3. AIR-COOLED CONDENSING UNIT

Air-cooled condensing unit shall be mounted in a weather-protected casing and shall be a complete factory-fabricated and assembled unit consisting of compressor, condenser, fan, electric motor drive and control panel.

3.1 Compressor shall be of the semi-hermetic reciprocating type for use with R-502 refrigerant and shall conform to Section: AIR CONDITIONING AND VENTILATION.

3.2 Condenser shall consist of Section: AIR CONDITIONING AND VENTILATION.

3.3 Direct-expansion fan coil unit shall be ceiling mounted type consisting of direct-expansion coil, fans, defrost heater, drain tray and pipes with heater, control box with heater, and casing. Fans shall be direct connected to electric motors. Other items shall conform to Section: AIR CONDITIONING AND VENTILATION.

SECTION 14G

FIRE EXTINGUISHER

1. The following hand portable fire extinguishers shall be provided and placed at each buildings as shown on the drawings. The extinguishers shall be wall mounted at a height of 800 mm above floor level, and shall comply with BS 5423 : 1977 or equivalent international standards and shall be of approved by the local Fire Authorities. Operating instructions shall be clearly printed on each unit.

   a) Carbon dioxide (CO_2) Extinguisher 5 lb. capacity
   b) Dry Chemical Extinguisher 5 lb. capacity

SECTION 15A

ELECTRICAL GENERAL

1. SCOPE OF PROJECT AND WORK

Work covered by these specifications shall include furnishing labor, materials, equipment, and service to be required for the construction of the following work in accordance with the tender drawings and the specifications herein. The work shall not be limited only for the electrical drawings but all other affiliated drawings pertaining with any electrical systems.

The main electrical work to be completed under this project shall consist of the following works:

A: Installation of medium voltage main circuit-breaker, an automatic voltage stabilizer, medium voltage distribution switchgear both for normal and emergency power supply systems, and associated electrical system including wiring in the Sub-station Building. However the following electrical work shall not be included as parts of this contract:

(a) Introduction of high voltage primary distribution cables to the premises.

(b) Furnishing and installing of high voltage switchgear and two power transformers and associating wiring system, except for that the furnishing and connections of medium voltage cables between the secondary terminals of the transformers, the main circuit-breaker and the switchgear which shall be furnished and installed by the Contractor.

B: Installation of all electrical equipment, devices, and wiring for the emergency power generating plant and system, including a generator and fuel system.

C: Installation of underground medium-voltage electrical distribution system between the Sub-station Building and the following buildings and facilities:

(a) Laboratory Building
(b) Aquarium Building
(c) Seed-Production Building
(d) Filtration Building
(e) Workshop Building
(f) Dormitory Building
(g) Intake Reservoir
(h) Area Lighting System

D: Installation of interior and area lighting and power systems as indicated on the drawings.

E: Installation of electrical system to be connected to the emergency power plant.

F: Installation of empty conduit system including terminal cabinet for Public Telephone System indicated on the drawings.

G: Installation of manual fire evacuation system indicated on the drawings.

H: All necessary control system wiring for lighting and power systems as indicated on the drawings.

I: Installation of manholes for telephone conduit system.

2. PLANS, DRAWINGS AND REGULATIONS

2.1 The tender drawings for this project shall serve as working drawings. They indicate the general layout of the complete electrical system such as medium-voltage main service, sub-main distribution system, final sub-circuits, lighting fittings, control switches, socket-outlets, heating and cooking appliance circuits, air-conditioning system's circuit, distribution boards, emergency electric service system, pumps control system, and other work indicated on the drawing.

2.2 Field verification as to real dimensions shall be accomplished by the contractor since the dimensions shown on the drawings may vary with the actual site locations.

2.3 The electrical contractor shall study architectural, structural, mechanical, and civil drawings to avoid possible installation conflicts. Should drastic changes from original drawings be necessary to resolve such conflicts, this Contractor shall notify the Engineer and shall secure from him written approval and agreement as to necessary changes and adjustments prior to any alteration of work. In any case such changes shall be planned strictly in accordance with the Regulations stated in other provision of these specifications.

2.4 Discrepancies shown on different drawings, or between drawings and actual field conditions shall be brought to the attention of the Engineer promptly for resolution.

2.5 Given drawings may be superseded by later revised drawings or specification addenda prepared by the Engineer, and the contractor shall conform to all reasonable changes without extra cost to the client. All items not specifically mentioned in the specifications or noted on the drawings, but which obviously are requried to make the working installation complete, shall be included automatically.

3. SHOP DRAWINGS PREPARATION

The contractor shall submit to the Engineer detailed, dimensioned shop drawings covering all items of equipment and devices, and brochures describing all lighting fittings, accompany with all technical data if required. No materials, devices, and equipment shall be ordered or scheduled for production until such shop drawings, brochures, and technical data have been approved by the Engineer.

The following procedure shall be carried out when shop drawings, brochures, and technical data are required. The contractor shall submit 4 prints of shop drawings, brochures, or technical data for approval. A copy of such submitted document will be returned to the contractor with comments or revisions by the Engineer.

After the approval of the Engineer as to such submissions, the contractor may commence the action of purchasing of the approved items.

4. APPROVAL PROCEDURES

The electrical products to be used on this project shall strictly conform with appropriate the British Standard Specifications (B.S.), unless otherwise specifically noted.

Acceptance or rejections of the substitutions shall be subject to the approval of the Engineer. The contractor shall submit sample of both the specified and the proposed substitutions items for inspection if the Engineer requests to do so. In all cases the contractor shall not be paid for extra cost for such substitutions.

5. MATERIALS AND SUBSTITUTIONS

Where materials, equipment, apparatus or other products are specified by manufacturer, brand names, or type or catalogue number, such designation is to establish standards of desired quality and style and shall be the basic of the tender. Materials so specified shall be furnished under the contract unless changes by mutual agreement. Where two or more designations are listed, choice shall be optional with the contractor. It is the intent of these specifications to establish quality standards of materials and equipment to be installed.

Hence, specific items are identified by manufacturer, trade name or catalogue designation. Should the contractor propose to furnish materials and equipment other than those specified, as permitted by the "or approved equal" clause, the contractor shall submit a written request for any or all substitutions to the Engineer.

Such request shall be an alternate to the original tender; shall be accompanied with complete descriptive (manufacturer, brand name, catalogue number, etc.) and technical data for all items; and shall indicate any addition or deduction to contract price. Where such substitutions require the alternation of the design or space requirements indicated on the drawings, the contractor shall include all items of cost for the revised design and construction, including cost of all allied trade involved.

6. CODES, REGULATIONS AND ORDINANCES

The electrical work under this contract shall be strictly governed by appropriate provision of the following Regulations:

(a) The Regulation for Electrical Installation work by the Government.

(b) The Electrical Supply Regulations, the latest edition issued by the Electricity Commissioner under the authority of the Electric Supply Acts.

(c) The Regulations for the Electrical Equipment of Building issued by the Institution of Electrical Engineers.

(d) Electrical (Factory Act) Special Regulations issued by the Department of Employment.

If the discrepancies between the above Regulations and these specifications or the drawings be found, the Regulations always govern the codes and rules. Should the contractor find such discrepancies, he shall report to the Engineer for the revision of the specifications or the drawings, except for the tropical ratings and current carrying capacity of cables shown on the drawings or in the specifications that is inevitably different.

7. SAFETY PRECAUTIONS

The contractor shall furnish and place proper guards for the prevention of accidents. The contractor shall provide and maintain any other necessary construction required to secure safety of life and property, including the maintenance of sufficient lights during such protection.

8. TEMPORARY SERVICES AND RELATED CONDITION

The electrical contractor shall furnish, install, maintain and remove after construction a temporary power and lighting systems. The source of power shall be obtained from the contractor owned generator plant or the available existing electrical power line. The necessary equipment and materials such as transformer, switchgear, and cables shall be furnished and installed by the contractor in accordance with the directive by the Engineer. In such case the contractor shall have to pay electricity bill according to the reading of the approved kilowatt-hour metre to be installed by the contractor and sealed by the Engineer upon commencement of service. The rate of electricity bill will be notified to the contractor prior to the service.

Temporary wiring installation shall be drawn on the drawing attached with a letter of request for the approval of the Engineer, and the electrical system shall be so designed that the system can supply sufficient electrical power to the project site for the purpose.

9. AMBIENT TEMPERATURES

9.1 The ambient temperatures to be affected to cables, motors, control-gear and ancillary apparatus for continuous and prolonged operation shall be as follows:

(a) Locations within buildings of substantial construction having good heat insulating properties & adequate ventilation ..... 110°F (43.3°C)

(b) Locations in well ventilated position and seldom from direct sun through the day (in building of light construction or of doors) ..... 120°F (48.9°C)

(c) Locations exposed to direct sunlight ..... 175°F (79.4°C)

(d) Minimum temperature likely to occur are

Outdoors	.....	30°F (-1°C)
Indoors	.....	40°F (5°C)

These temperatures make no allowance for produced in or by electrical equipment or apparatus itself or in any adjacent equipment, whether electrical or otherwise.

9.2 Other than those which are specially designed for high temperatures shall not be installed in any duct, conduit, or trunking in which ambient air temperatures are likely to exceed the following values:

Type of insulation	Maximum temperature of ducts or cable surroundings	
Rubber	55°C	131°F
P.V.C.	65°C	149°F
Polythene	65°C	149°F
Impregnaged paper	75°C	167°F
Varnished camblic and heat-resisting fibre	80°C	176°F
Silicon rubber	145°C	293°F
Butyl rubber with heat-resisting fibre	80°C	176°F
Mineral insulated	145°C	293°F

If temperatures over 145°C are likely to be continued, special heat-resistant cables shall be used.

10. INSULATION CLASSES

Classes of insuration materials used for all electrical equipment applicable shall be defined as follows:

Class of insulation	Maximum allowable full-load temperatures (°C)
Y	90
A	105
E	120
B	130
F	155
H	180
C	over 180

It is defined that temperature rise on the electric equipment shall be the temperature differencial between measured temperature on the equipment and ambient temperatures.

11. SYSTEM VOLTAGES

The electrical system voltage ranges to be dealt with this project shall be as follows:

(a)	extra-low voltage;	normally not exceed 50 volts between conductors, and not exceeding 30 volts a.c. or 50 volts d.c. between any conductor and earth.
(b)	low voltage;	normally exceeding extra-low voltage but not exceeding 250 volts between conductor to earth.
(c)	medium voltage;	normally exceeding 250 volts but not exceeding 650 volts, whether between conductor or earth.
(d)	high voltage;	normally exceeding 650 volts, whether between conductor or to earth.

12. VOLTAGE DROP

The voltage drop between the supply terminals and any, or every, point in the installation shall not exceed 2.5 per cent of the declared voltage. The declared voltage is the voltage declared by the Supply Undertaking and not necessarily the actual voltage at the supply terminals which may vary 6 per cent above or below the declared voltage, as defined by Electricity Supply Regulation 34 (b).

With a declared voltage of 240 volts, the actual voltage may be anything between 225 and 254 volts but the voltage drop calculation shall be based upon 240 volts, and therefore, the maximum drop shall not be allowed in any part of the installation exceeding more than 2.5 per cent of 240 volts, which is 6 volts.

13. CIRCUIT CATEGORY AND SEGREGATION OF CONDUCTORS

13.1 The electrical wiring systems for this contract shall be categorized as follows:

(a) Category 1 circuits

Circuits (other than fire-alarm circuits) operating at low or medium voltage and supplied directly from a main supply system.

(b) Category 2 circuits

With the exception of fire-alarm circuits; and telecommunication circuits (e.g. radio, telephone, sound-distribution, burgular-alarm, bell and call circuits) which are not supplied directly from a main supply system.

(c) Category 3 circuits

Fire-alarm circuits.

13.2 Cables of Category 1 circuits shall not be drawn into the same conduit or duct as cables of Category 2 circuits, unless the latter cables are insulated for the highest voltage present in the Category 1 circuits.

13.3 Cables of Category 1 circuits shall not be in any circumstances be drawn into the same conduit or duct as cables of Category 3 circuits.

13.4 Cables of Category 1 and cables of Category 2 circuits can be drawn into a common channel or trunking if effective partition be provided between two circuits, or the cables of Category 2 has the same insulation with highest voltage cables in Category 1 circuits.

Where a common channel or trunking is used to contain cables of Category 1 and Category 3 circuits, two categories of circuit shall be separated by continuous partition of fire-resisting material unless the Category 3 circuits are wired in mineral-insulated metal sheathed cable.

13.5 In conduit, duct, or trunking systems, where controls or outlets for Category 1 and Category 2 circuits are mounted in or on common boxes, the cables and connections of the two categories of circuits shall be partitioned by means of rigidly fixed screen or barriers.

At any common outlets in a trunking system for Category 1 and Category 3 circuits, the two categories of circuits shall be separated by continuous partitions of fire-resisting material.

13.6 Electrical services shall not be installed in the same conduit or trunking as pipes or tubes of non-electrical services, e.g. air, gas, oil, or water.

14. REQUIREMENTS FOR SAFETY

All electrical conductors shall be of sufficient size and current rating for the purpose for which they are used. Every electrical circuit and sub-circuit and final sub-circuit shall be protected against excess current by fuses, circuit-breakers, or other similar devices.

Where the earth-fault-leakage current from a circuit due to fault of negligible impedance from a live conductor to earthed metal is insufficient to operate the fuses or circuit-breakers, the earth-leakage circuit-breakers or equivalent device shall be used.

No fuse, or circuit-breaker other than a linked circuit-breaker, shall be inserted in a conductor connected with earth, and any linked circuit-breaker inserted in a conductor connected with earth shall be arranged to disconnect also all live conductors.

Every non-current carrying metal parts shall be earthed. Every electric motor shall be controlled by efficient switch for starting and stopping, such switch to be readily accessible and easily operated and so placed as to prevent danger.

Conductors and apparatus operating at voltage between conductors or to earth exceeding 250 volts shall be completely enclosed by earthed robust metallic enclosure.

15. EARTHING

15.1 Every item of apparatus and every conductor operating at a voltage exceeding extra-low voltage shall be of all-insulated construction type or be earthed.

15.2 All metal work of wiring systems (other than current carrying part), including cable sheath and armour, conduit, ducts, trunking, boxes, and catenary wires, shall be earthed properly.

15.3 Earth continuity conductors shall be copper conductor and be connected to earth-bus with earthing rod as shown on the drawing. Minimum size of copper earthing leads, copper bonding leads, and copper earth-continuity conductors not contained in a composite cable, flexible cable, or flexible cord shall not be smaller than sizes shown as follows:

(Unit: mm^2)

Nominal cross-sectional area of largest associated copper circuit conductor	Nominal cross-sectional area of earthing lead	Nominal cross-sectional area of earth-continuity conductor	Nominal cross-sectional area of bonding lead
1	2	3	4
1.0 sq.mm	6 sq.mm	1.5 sq.mm	1.5 sq.mm
1.5	6	1.5	1.5
2.5	6	1.5	1.5
4	6	2.5	1.5
6	6	2.5	1.5
10	6	6	2.5
16	6	6	2.5
25	16	16	6
35	16	16	6
50	16	16	6
70	50	50	16
95	50	50	16
120	50	50	16

150	50	50	16
185	70	70	50
240	70	70	50
300	70	70	50
400	70	70	50
500	70	70	50
630	70	70	50

15.4 A current-operated earth-leakage circuit-breaker shall be used where indicated on the drawings or required by the Regulations. In such cases, the earth-loop impedance shall not exceed 40 ohms, and earthing terminals shall be connected to suitable electrodes.

The operating current of a current operated earth-leakage circuit-breaker shall not exceed 2% of the normal rated current of the circuit. Operating current shall be less than 500 ma.

15.5 Pipes such as gas or water pipes, or member of structural metal work, shall not by themselved continue on earth-continuity conductor, but it is admissible to bond them to earth-continuity conductor where this is necessary for compliance with the I.E.E. Regulations.

15.6 Earth-leakage protection may be afforded by mean of fuses or excess-current circuit-breakers, the circuit shall be dead when the fault circuit current exceeds.

(a) 3 times the current rating of any semi-enclosed fuse, or any cartridge fuse having a fusing factor exceeding 1.5, used to protect the circuit, or maximum earth-loop impedances for earth-leakage protection by semi-enclosed fuses, or cartridge fuses having a fusing factor exceeding 1.5.

(System operating at 230-250 volts to earth*)

Current rating of fuse	Impedance
amperes	ohms
5	16
10	8
15	5.3
20	4
30	2.7
45	1.8
60	1.35
100	0.8

* For system of any other voltage E to earth the impedance value, tabulated are to be multiplied by E/240.

(b) 2.4 times the rating of any cartridge fuse having a fusing factor not exceeding 1.5, used to protect the circuit, or

(c) 1.5 times the tripping current of any excess-current circuit-breaker used to protect the circuit.

For a socket-outlet of rating 15 amperes or less, the impedance of the earth-loop should not exceed more than 4 ohms.

15.7 Earthing bus size shown on the drawing shall be installed where indicated on plan and be connected to earthing electrodes by means of earthing leads.

15.8 Main earth electrode shall be supplied and installed near the service and shall consist of made electrodes of copperweld steel, and those shall be driven into ground at least 3 metres.

15.9 From the earth electrodes to the any position of steel conduit, trunkings, and enclosures the resistance of the earthing lead shall not exceed more than 0.5 ohms.

15.10 A substantial stranded earth continuity conductor shall connect the earth pin of all socket-outlets, and any runs of conduit and metal cases and sheathing not otherwise in continuous and effective metallic contact with the main earth electrode. Such earth continuity conductor shall run in one continuous length from the farthest point of the installation to the main electrode and shall be connected by branch conductors to all other metal casing and sheathing housing electrical apparatus. All branches shall be connected to the main conductor by approved method. The series earthing of one piece of apparatus to another shall not be permitted except in the socket-outlets connected to a ring circuit.

15.11 Where wiring is enclosed in a continuous system of metallic conduit, such conduit will be accepted as an earth continuity conductor provided all joints are electrically sound and the specified resistance figures can be obtained and maintained.

15.12 The main earth continuity conductor from the main switch or circuit-breaker to the earth electrode shall not be run through steel or other magnetic conduit or duct, but shall be protected from damage by suitable sheathing which shall not completely encircle the earth conductor, if the sheathing is of steel or other magnetic materials.

Note: This shall not apply to earth conductors run in the same conduit as all wires of the circuit which it protects.

16. ELECTRICAL INSULATION TESTS

16.1 The electrical contractor shall test all wiring and connections for continuity and earthing before equipment be installed.

Such testing shall be performed in accordance with the supervision of the Engineer. This contractor shall also test all medium-voltage distribution cables after installation and before energizing by applying potential. Test period shall be not less than the time directed by the applicable regulations or codes.

Before energizing the system, the contractor shall inspect all connections and set all relays and instruments for proper operation. The contractor shall obtain necessary clearances, approvals and instructions from the undertaking authority.

Test procedure, conduct of tests, and documentations of test shall be in accordance with the applicable British Standard Electrical Code of Practice.

16.2 Every installation on completion shall be inspected and tested in accordance with the I.E.E. Regulations.

16.3 A verification of polarity shall be made in accordance with the I.E.E. Regulations.

16.4 Prior to an installation putting into commission, a separate test of every earth continuity conductor shall be made by the contractor under the supervision of the Engineer in accordance with the I.E.E. Regulations.

16.5 Where the operation of excess-current circuit-breakers are used for earth-leakage protection of the circuits, the contractor under the supervision of the Engineer shall carry out earth-loop-impedance test in accordance with the I.E.E. Regulations.

16.6 Where earth-leakage circuit-breakers are used for protection of earth-leakage of the circuits, the contractor under the superision of the Engineer shall carry out effective test of the earth-leakage circuit-breakers in accordance with the I.E.E. Regulations.

16.7 Minimum installation resistance of a complete circuit, all switches in closed position, to earth shall not be less than 1 megohms.

16.8 Where measured between all the conductors connected to any one pole or phase ofthe supply, the insulation resistance between two conductors shall not be less than 1 megohms.

16.9 The insulation resistance of the case or frame work to earth shall not be less than 0.5 megohms after disconnecting from source made.

16.10 The continuity of all conductors of ring circuit shall be tested.

16.11 All insulation test described hereto shall be carried out before a completed installation is permanently connected to the supply. For these tests large installations may be devided into groups of outlets, each containing not less than 50 outlets. A d.c. voltage not less than twice the normal voltage of supply shall be applied for the measurement of insulation resistance, provided that for test on medium-voltage circuit the test voltage need not exceed 500 volts d.c.

16.12 All results of insulation test shall be recorded and submitted to the Engineer.

17. DISTINCTIVE COLOUR FOR CONDUCTORS AND CABLES

17.1 All bus-bars and cables shall be coloured with correct distinctive colours as specified following:

(a) Two-wire d.c. system

Red for positive or switch wire.
Black for negative.

(b) Two-wire d.c. from a 3-wire d.c. system

Red for outer or switch wire.
Black for middle wire.

(c) Three-wire d.c. system (or two outer of a 3-wire d.c. system)

Red for positive or switch wire.
Black for negative or switch wire.

17.2 A.C. system shall be coloured with correct distinctive colours as specified as follows:

(a) Two-wire a.c. single phase system

Red for phase-line or switch wire
Black for neutral.

(b) Three-wire single-phase system

Red for switch wire or one conductor.
Black for 'middle' wire.
Yellow for switch wire or other conductor.

(c) Two-phase 3-wire system

Red one phase.
Black common return.
Yellow other phase.

(d) Four-wire or 3-wire 3-phase system

Red for first phase.
Yellow for second phase.
Blue for third phase.
Black for neutral (in 4-wire systems)

(e) Four-wire 2-phase system

Red for one phase.
Yellow for other phase.

17.3 Flexible earth cords shall be coloured with green or green/yellow.

17.4 Flexible cords colour distinctions:

When three-core flexible cord are used the colours of the cords shall be brown (connected to phase or live side), blue (connected to neutral or return), and green/yellow (connected to earth).

When four-core flexible cords are used for fixed or portable fittings that have to be earthed, the colours of the cores shall be brown (connected to phase or live side), blue (connected to neutral or return), and green/yellow (connected to earth).

SECTION 15B

MEDIUM-VOLTAGE DISTRIBUTION SYSTEM

1. GENERAL

(a) The main distribution centre of the electrical system to the whole facilities of this project site shall be the Sub-station Building which shall consist of the following rooms:

(a) High-voltage switchgear room.
(b) Transformer room.
(c) Medium-voltage switchgear room.
(d) Emergency generator room.

The description of the equipment to be installed in the above stated rooms are described in the following provision of these specifications, except for the high-voltage switchgear and two transformers which shall be furnished and installed by the M.P.W.

2. PRIMARY ELECTRICAL SYSTEM

The primary electrical distribution system to be introduced in to the premisis by the M.P.W. will be dual service of 3-phase 11 K.V. 50 H.Z. underground cables. The cables shall be brought and introduced by other up to the high-voltage switchgear room in the Sub-station via manholes and ducts to be constructed by the contractor in accordance with the drawing. Those high-voltage cables will be connected with the two primary circuit breakers and primary terminals of two transformers respectively. All equipment and materials shall be furnished and installed by other.

3. SECONDARY ELECTRICAL DISTRIBUTION SYSTEM

The contractor shall furnish and install the following equipment and also install the secondary distribution cables:

(a) Main medium-voltage switchgear. See 15C-3.
(b) Automatic voltage stabiliser. See 15C-1.
(c) Medium-voltage Distribution switchgear, for normal power system. See 15C-3.
(d) Medium-voltage distribution switchgear, for emergency power system. See 15C-3.
(e) Diesel Engine Driven emergency generator plant and all necessary ancillary equipment and devices.

The descriptions of the above stated items shall conform to the other provision of these specifications. See 15D.

4. SECONDARY ELECTRICAL DISTRIBUTION SYSTEM EQUIPMENT

The equipment shall consist of the items (a) through (d) stated in para. 2. above, and those shall be assembled as a unit structure as indicated on the drawings. However the contractor shall realise that the dimensions shown on the drawings are for reference only.

5. MEDIUM-VOLTAGE MAIN CABLES CONNECTIONS

The contractor shall furnish p.v.c. insulated, p.v.c. extruded wire armoured cables sizes indicated on the drawing, between the secondary terminals of the transformer and the supply side terminals of the main circuit-breaker.

6. TRANSITIONS

The connections between the main circuit-breaker, automatic voltage stabiliser, and medium-voltage switchgear shall be made by means of the factory fabricated copper bus transition section having the full rated current carrying, and rupturing capacities identical to the bus of the main bus. The shop drawings of the sections shall be submitted to the Engineer for his approval.

7. MEDIUM-VOLTAGE DISTRIBUTION SYSTEM

The medium-voltage distribution systems in this situation shall consist of the following systems:

(a) Normal power system, which shall be fed by the city electrical power service and to feed all electrical load to be required by the buildings and area lighting, including air-conditioning systems, water pumps and air blowers systems.

(b) Emergency power system, which shall be produced by a diesel engine driven generator and only to feed all water pumps and air blowers incase of the outage of the city electrical power service.

8. MEDIUM-VOLTAGE DISTRIBUTION FEEDER SYSTEM

The medium-voltage feeders to the buildings, facilities, and area-lighting system shall be completed by p.v.c. insulated and p.v.c. extruded cables in concrete encased duct system as indicated on the drawings. The duct shall be nonmetallic conforming to B.S., and the sizes indicated on the drawing may indicate equivalent sizes to the B.S. or nearly equals. The locations of the manholes and duct banks shown on the drawings may be varied due to the condition of the site, the contractor shall submit shop drawing of such layout prior to excavation.

9. COORDINATION OF CIRCUIT-BREAKERS CHARACTERISTICS

Upon selection of the circuit-breakers, the contractor shall carefully study the characteristics of the circuit-breakers against short circuit current. The coordinations of the circuit-breakers in the system shall be very important and no case that be allowed the main circuit-breaker be tripped prior to the clearance of the sub-main or smaller circuit-breakers in the system. The contractor shall obtain the characteristic curves of all circuit-breakers to be used and the coordination analysis shall be submitted to the Engineer.

10. CONCRETE AND STEEL REINFORCING BARS

The concrete and steel reinforcing bars to be used for the construction of duct system and manholes shall conform to the other section of these specifications.

SECTION 15C

ELECTRICAL INTERIOR POWER AND LIGHTING SYSTEM

1. AUTOMATIC VOLTAGE STABILISER

1.1 General

Where indicated on the drawings, the contractor shall furnish and install an automatic voltage stabiliser completed with full automatic control gear.

The voltage stabiliser shall be of no brushes induction type, and rated for the system indicated on the drawings.

The voltage stabiliser shall be applicable to electrical circuits in industrial plants or commercial buildings to perform either of two functions:

(a) Maintain a constant voltage or current despite variations in the supply voltage or the connected load.

(b) Provide a widely adjustable output voltage or current from an essentially constant supply.

The voltage stabiliser shall be used successfully in applications like the follows:

(a) Computers
(b) Long Feeder Runs
(c) Electronic Equipment
(d) Lighting
(e) Air-conditioning Equipment
(f) Communication Equipment
(g) Temperature Control
(h) Electrical Planting
(i) Rectifier

The voltage stabiliser shall not introduce harmful waveform distortion.

Load power factor shall not be affected on the output voltage of automatic voltage stabilisations.

Drift-Free control system shall hold voltage automatically within $\pm$1% bandwidth. The compensated controls on the stabiliser shall make it unnecessary to continually reset voltage level.

The control shall be compensated also ambient temperatures and frequency.

Electrically the voltage stabiliser shall withstand up to 15 times normal short circuit current.

The voltage stabiliser shall withstand up to a 100% overload for one hour while maintaining excellent long-life operating characteristics.

1.2 Automatic control:

The control for voltage stabiliser shall use integrated circuits, and shall completely be static with the exception of the motor starter contactors or relays.

They shall be designed to maintain output voltage within ±1% over an ambient temperature range of minus 30°C to plus 45°C. Each control shall sense output voltage with an internal potential transformer.

The range of adjustable voltage shall be 20% and can be adjusted by a potentiometre on the front panel. The output voltage level shall be selected in relation to the input voltage affects the regulating range of the stabilizer.

Setting of control adjustment for a given output voltage, shall make the stabiliser sense any voltage variation automatically and maintain preselected output voltage.

1.3 Ratings:

The voltage stabiliser shall be dry-type or safety-oil insulated type in accordance with standard of the manufacture, the stabiliser shall be either self-cooled or forced-cool for indoor use.

The K.V.A. rating shall be in accordance with the K.V.A. rating of the power transformer which will be the source of the electric service of the system. The voltage stabiliser shall be suitable for the three phase 400 volts, 50 Hz incoming service, and the range of the voltage regulation shall be ±20%.

1.4 Performance:

The voltage stabiliser shall start correction in 4 cycles, and complete the regulation within 1 second for usual 25 change in line voltage.

The control bandwidth shall be ±1%, and control accuracy shall be not more than 1%.

The efficiency of the voltage stabliser shall be not less than 99%.

1.5 Overcurrent protection:

The automatic voltage stabiliser shall be connected to the secondary terminals of the government furnished main transformer via the contractor furnished and installed circuit breaker of which rating shall be as indicated on the drawings.

1.6 Enclosure and Earthing:

The voltage stabiliser shall be encased within the robust steel enclosure of which colour shall be subject to the approval of the Engineer. And the stabiliser shall be earthed completely in accordance with the instruction of the manufacturer.

1.7 By-Pass Circuit:

In case of the maintenance and repair of the voltage stabilizer, a compartment of by-pass circuit consisting of manual change-over circuit-breaker as indicated on the drawing shall be connected with the system circuit-breaker, voltage stabilizer, and/or main bus directly.

2. CONTROL, DISTRIBUTION AND EXCESS-CURRENT PROTECTION

2.1 General

The electrical installation for this contract premises shall be adequately controlled by switchgear readily accessible to the qualified person which shall incorporate:

(a) means of isolation, and
(b) means of excess-current protection, and
(c) means of earth-leakage protection.

The means of isolation shall comprise a linked switch suitable for operation on load or a linked circuit-breaker, arranged to disconnect all circuit conductors of each installation from the supply. Alternatively for 4-wire three-phase A.C., 3-wire single-phase A.C. or 3-wire D.C., supply, where one conductor is connected with earth, the linked switch or circuit-breaker may be arranged to disconnect the live conductors only.

The means of excess-current protection shall comprise either a fuse inserted in each live conductor of the supply or a circuit-breaker having an excess-current release fitted in each live conductor of the supply.

Every conductor in the installation shall be protected against excess-current by a fuse or circuit-breaker fitted at the origin of which the conductor form part. The current rating of fuse used for this purpose shall not exceed amperage of the lowest-rated conductor in the circuit. Every circuit-breaker used for this purpose shall operate when the circuit protected is subject to sustained excess current of 1.5 times the rating of the lowest-rated conductor in the circuit.

2.2 Rupturing capacity:

All excess-current protective devices shall have enough rupturing capacities as indicated on the drawing enable to clear out the circuit from short circuit current.

Those devices shall be well coordinated so that the nearest locating excess-current device from the point of short circuit occurrence shall be actuated first.

The manufacturer's curves of coordination curves of each device shall be submitted to the Engineer by the Contractor.

3. MEDIUM-VOLTAGE SWITCHGEAR

3.1 Main switchgear

The Contractor shall furnish and install a dead front, fixed type, metal-enclosed self-supporting switchgear consists of the follows:

(a) Metreing compartment.
(b) Two topless circuit-breakers for secondary disconnection of two transformers.
(c) A main system circuit-breaker.
(d) A manual change-over circuit breaker for by-pass circuit of the automatic voltage stabilizer.

Buss shall be of copper tropical rated throughout all switchgear, and the rating of the circuit-breakers shall be as indicated on the drawings.

3.2 Sub-feeder switchgear:

Sub-feeder switchgear for both normal and emergency electrical distribution system shall be installed adjacent to the automatic voltage stabiliser in the Sub-station building.

The switchgear for normal power system shall be directly connected to the secondary terminals of the automatic voltage stabiliser.

The switchgear for the emergency power system shall also be fed from the automatic stabiliser, however, the switchgear shall be fed through the automatic changeover switch to be backed up by the emergency generator, which shall be installed in the generator room.
Both switchgears shall consist of moulded case earth-leakage circuit breakers of which ratings are indicated on the drawings.

3.3 Secondary distribution system

Through the normal power switchgear the lighting, socket-outlets, air-conditioning, and area lighting systems in entire buildings and facility shall be served by feeders of 3 phase 4 wire 240/415 volts, or 1 phase 2 wire 240V 50 Hz system.

The emergency switchgear shall supply the power for water pumps, sea water intake pumps, city-water pumps, and blowers.

3.4 Circuit identifications:

All main and sub-main circuit-breaker cubicles shall be provided with plastic boards which indicate the description of the load to be connected to the circuit-breakers. The letters shall be engrave on White colour plastic boards, the height of the letters shall be approximately 30 mm and the stroke shall be 3 mm, the

colur of the letters shall be black or red.

Each compartment of switchgear shall be provided with illuminated identification board. The source of illumination shall be fluorescent lamps.

All power and control cables shall be provided with made terminal markers, make shift terminal markers shall not be used.

3.5 Installation location:

The medium-voltage main switchgear, automatic voltage stabiliser, and switchgear for normal and emergency power distribution switchgear shall be situated as one unit power center type electric equipment, and shall be situated in the Meidum-voltage switchgear room of the Sub-station Building.

All electrical equipment shall be earthed completely.

3.6 Earthing copper bus:

Bare copper earthing buses shall be installed in the rooms of the Sub-station Building as indicated on the drawing, and bonded together then earthed to ground by means of copper-clad steel rods. Sufficient numbers of earthing rods shall be diven into ground until required registance value of earthing system is obtained.

The size of copper buses shall be 50 mm wide and 5 mm thick, and shall be securely supported on the wall at every 1 metre.

Bonding of bus and earthing conductor shall be made by means of proper pressure type earthing terminals, or by cadwelding method.

4. MAIN AND SUB-MAIN DISTRIBUTION BOARDS

Where shown on the plans or diagrams, and listed in the distribution board schedules, the contractor shall furnish and install distribution boards of the types and sizes noted. Mounting height of board to top of cabinet shall be 1.8 metres above the finished floor.

Distribution boards shall be equipped with the moulded case thermal and magnetic circuit-breakers and the type of construction shall be dead-front incorporating hinged cover. The distribution boards shall be provided with a main circuit-breaker or main lugs only as indicated on the drawings.

Bus shall be of copper and for voltage as noted on the drawing, however, ampere rating shown on the drawing shall be construded as the tropical rating which requires larger dimensions than standard

size bus for the same ampere rating, so that the distribution board shall be serviceable in the use at ambient temperatures of 50°C. When the standard bus be used, such ampere rating shall be applied with rating factor in accordance with requirement in other provision of these specifications.

Bus also shall have sufficient capacity to feed the enough number of circuit-breakers indicated on the drawings. All circuit-breakers shall be of "bolted-on" type to the bus, "plug-in" type circuit-breakers shall not be used. Distribution board assembly shall be enclosed in a code-gauge steel cabinet of robust construction, with flush or surface mounted type and ample wiring space on top, sides, and bottom. Cabinet doors shall be equipped with spring latches and locks, all distribution boards shall be opened by a master key. Number of master key to be turned in to the Engineer shall be five.

All bus shall be color distinctive in accordance with other provision in these specifications. The size of neutral, and earthing buses shall have full ampere capacity of phase buses, and the number of cable terminals shall have ample spaces for future wiring.

Neutral bus shall be insulated from cabinet. Where multiple cables to be connected to a phase lug, such terminal lugs shall be made for multi-cable connection purpose. Not more than one cable shall be connected to any conventional type lugs.

Distribution boards shall be fabricated in accordance with all requirements in B.S. 3676.

Moulded case circuit-breakers shall conform to B.S. 3871 or equal.

Where indicated on the drawings, distribution board shall equip earth-leakage circuit-breaker/s.

Each distribution board shall have a circuit schedule pasted or otherwise permanently fixed inside the door or adjacent to the distribution board. All such schedules shall be in Arabic and English.

5. LIGHTING & SOCKET-OUTLETS DISTRIBUTION BOARD

This distribution board shall feed final sub-circuits.

All lighting & socket-outlets final sub-circuit distribution boards shall be of the bolted-on miniature circuit-breaker type of size indicated on panel schedules. Distribution boards shall be arranged for service on 240 volts, single-phase, 2-wire system unless otherwise specified on the drawings.

All final sub-circuit distribution board shall be of the bolted-on miniature circuit-breaker type of sizes indicated on panel schedules. Distribution boards shall have earth-leakage main circuit-breaker with sensitivities of not larger than 500 ma. on the main bus bar. The earth-leakage circuit-breaker shall break phase and neutral

conductors simultaneously. Earth-leakage circuit-breakers shall conform to B.S. 4293.

Bus ampere rating shown on the drawing shall be construded as tropical ratings, and be colour distinctive, and bus shall be of all copper.
Cabinets of distribution board shall be of code-gauge thickness steel with ample wiring spaces for all cable and connections.

Door shall be the single type with spring latches for flush or surface mounting as noted.

Five each of master keys shall be furnished and turned in to the Engineer.

Each distribution board shall be provided with insulated neutral bar and earthing terminal bar, both shall be provided enough space for additional future wiring.

The colour sample of distribution boards shall be submitted to the Engineer for his approval.

All distribution boards shall be standard product of leading manufacturer and conforming with British Standard Specifications.

In case two or more distribution boards be fed from other phase of medium-voltage system, minimum distance between those shall not less than 2 metres, or warning signboard "DANGER 400 VOLTS" shall be provided. Sample of signboard will be given by the Engineer.

Each distribution board shall have a circuit schedule pasted, or otherwise permanently fixed inside the door or adjacent to the distribution boards, in both Arabic and English.

No switch or circuit-breaker controlling more than one phase shall break any neutral conductor. All switch or circuit-breakers controlling circuits containing more than one phase shall break all phases simultaneously.

No fuse or circuit-breaker shall be inserted in the neutral conductor in any part of an installation.

No distribution board shall be mounted in such a position that it can be touched by any person at the same time as any water taps, basin sink, bath, metal drawing board, etc. the minimum acceptance from baths and showers shall be normally 2.45 metres and from other plumber's fittings 2 metres.

Maximum number of excess-current protective elements shall be no more than 36 in one distribution board.

6. ELECTRIC MOTORS

6.1 General

The Contractor shall furnish and install all electric motors and controllers shown on the drawings, an isolator for each motor where indicated, and required power and control circuits as indicated on the drawings. All motors and controllers shall be delivered to the receiving dock at the jobsite. Unless otherwise noted, the contractor shall receive, handle, set, mount, install and connect this equipment where indicated on the drawings.

6.2 Motor enclosures:

The types of motors described on the drawings or in the specifications shall be defined as follows:

(a) Open, General Purpose: Ventilated openings permit passage of external cooling air over and around the windings of the machine.

(b) Open, Drip-proof: Ventilating openings are so constructed that successful operation is not interfered with when drop of liquid or solid particles strike or enter the enclosure at any angle from 0 to 15 degrees downward from the vertical.

(c) Open, Splash-proof: Ventilating openings are so constructed that successful operation is not interfered with when drops of liquid or solid particles strike or enter the enclosure at any angle not greater than 100 degrees downward from the vertical.

(d) Open, Guarded: Openings giving direct acdess to live or rotating parts (except smooth shafts) are limited as to size by the design of the structural parts or by screens, grills, expanded metal, etc., to prevent accidental contact with such parts.

(e) Open, Semiguarded: Part of the ventilating openings, usually in top half, are guarded as in a guarded machine, but others are left open.

(f) Open, Drip-proof, Fully Guarded: A drip-proof machine with ventilating openings as in a guarded machine.

(g) Open, Externally Ventilated: A machine which is ventilated by means of a separate motor-driven blower mounted on machine enclosure.

(h) Open, Pipe-Ventilated: Openings for admission of ventilating air are so arranged that inlet ducts or pipes can be connected to them.

(i) Open, Weather-Protected: TypeI: Ventilation passages are so designed as to minimize the entrance of rain, snow and airborn particles to the electrical parts. Type II: Ventilating

passages at intake and discharge are so arranged that high-velocity air and airborn particles blown into machine by storms or high winds can be discharged without entering the internal ventilating passages leading directly to the electric parts.

(j) Open, Encapsulated Windings: An alternating-current squirrel-cage machine having random windings filled with an insulating resin which also forms a protective coating.

(k) Open, Sealed Windings: An alternating-current squirrel-cage machine making use of form-wound coils and having an insulation system which, through the use of materials, processes, or a combination of materials and processes, results in a sealing of the windings and connections against contaminants.

(l) Totally Enclosed, Non-Ventilated: Enclosure orevents free exchange of air inside and outside of case, but not airtight.

(m) Totally Enclosed, Fan-Cooled: Equipped for exterior cooling by means of a fan, integral with machine, but external to the enclosing parts.

(n) Totally Enclosed, Fan-Cooled, Guarded: All openings, giving direct access to fan, are limited in size by design of structural parts or by screens, grills, expanded metal, etc., to prevent accidental contact with fan.

(o) Totally Enclosed, Flame-Proof: Design and built to withstand an explosion of gas or vapor within it and to prevent ignition of gas or vapor surrounding machine by spark, flashes, or explosions which may occur within machine casing.

(p) Totally Enclosed, Dust-Ignition-Proof: Designed and built to exclude ignitible amounts of dust, or amounts affecting performance or rating, to prevent ignition of exterior dust on or in vicinity of enclosure.

(q) Totally Enclosed, Pipe-Ventilated: Openings os arranged that inlet and outlet ducts or pipes may be connected to them for admission and discharge of ventilating air.

(r) Totally Enclosed, Water-Cooled: Cooled by circulating water; the water or water conductors come in direct contact with the machine parts.

(s) Totally Enclosed, Water-Air-Cooled: Cooled by circulating air which in turn is cooled by circulating warer.

(t) Totally Enclosed, Air-to-Air Cooled: Cooled by circulating internal air through heat exchanger which, in turn, is cooled by circulating external air.

7. TRANSFORMERS FOR SMALL POWER SUPPLY AND CONTROL POWER

7.1 General

Where indicated on the drawings, the Contractor shall furnish and install all dry type transformers. Transformers shall be rated as indicated on the drawings. Unless otherwise specified transformer shall be used forthe purpose of stepping down medium voltage to low voltage, primary and secondary coils shall be wound separately, and core and case of transformers and one leg of secondary terminals shall be connected to earth continuity conductors. Encasement of transformers shall be robust and treated with rust inhibiting coatings and the colour of finishing paint shall be approved by the Engineer.

7.2 Noise levels:

For location where quiet operation of transformers is essential, the sound level of transformers shall not exceed more than 40 db., for single or three phase rated 600 volts or less, 9 kVA or less.

7.3 Insulation class:

Insulation class of dry type transformer shall be class H, unless otherwise specified on the drawing.

7.4 Excess-current protective devices:

The primary and secondary ungrounded conductors shall be provided with excess-current protective device such as fuse or circuit-breaker of which rating not more than 125% of the rated current of the transformer. In no case the current carrying capacity of the primary and secondary conductors shall not be less than 125% of the rated current of the transformer.

7.5 Control circuit transformers:

Where specified on the drawings, control transformers shall be provided to obtain 110 volts A.C. control power for motor controllers, magnetic contactors, or other devices requiring such low voltage. The control transformer shall be type of individually mounted in the enclosure of each electric device, or the type large enough to feed a group of such devices.

7.6 Excess-current protection:

All control transformers shall be single phase, dry-type and ungrounded leg shall be protected by fuse, of which capacity is not larger than the rating of transformer.

7.7 Rating:

A control circuit transformer shall not overheat when operated as its maximum continuous volt-ampere (v.a.) rating, nor shall its secondary output voltage fall below 95% of rated output voltage when selected according to the following recommendations:

(a) The continuous V.A. capacity of the transformer shall be equal to or greater than any continuous maximum V.A. requirement of the controller.

(b) The inrush V.A. capacity of the transformer shall be equal to or greater than maximum V.A. inrush which can occur for any combination of sealed and inrush V.A. requirement of the controller.

The V.A. values which fulfill these requirements shall be calculated by the manufacturer of the controllers.

8. LIGHTING SYSTEM

8.1 General

The Contractor shall furnish and install all lighting fittings, associated wiring, controls, and distribution boards in accordance with the drawings. All lighting fittings and associated devices and materials shall be delivered to the construction places after obtaining the approval of the Engineer. The type, size, and rating of the lighting fittings shall be as indicated in the lighting fitting schedule on the drawings. Where special lighting equipment other than standard products of the manufacturer are required on the drawings, actual scaled shop drawing showing the details of such lighting equipment shall be submitted to the Engineer for approval.

8.2 Lighting fittings:

All indoor use lighting fittings shall be fabricated strictly in accordance with the relative British Standard Specifications, e.g.,

(a)	Fluorescent fittings	B.S. 4533-2.2 (1P20)
(b)	Battery operated transistorises fluorescent fittings	Class II B.S. 4533-2.2 (1P20)
(c)	Circuline fluorescent fittings	B.S. 4533-2.2 (1P20)
(d)	Bathroom model with shaver outlet	B.S. 4533-2.2 (1P20) & B.S. 3052
(e)	Flame-poor fluorescent fittings	B.S. 229, B.S. 4533-2.2 (1P65)
(f)	Dust-tight fluorescent fittings	B.S. 889, B.S. 4533-2.2 (1P65)
(g)	Rain-proof type fittings	B.S. 4533-2.2 (1P23)
(h)	Corrosion resisting fittings	B.S. 4533-2.1 (1P54)
(i)	Exit sign fittings front panel	B.S. 5266

(j)	P.V.C. film used in fittings	B.S. 1763, 2782
(k)	Light trunking	B.S. 2260.9
(l)	Interior discharge lamp fittings	B.S. 4533-2.2 (1P22)
(m)	Ditto Drip-proof	B.S. 4533-2.2 (1P22)

All outdoor lighting or floodlighting fittings shall be of rain-proof type conforming to B.S. 1P23 and be provided with Class 1 earthed metalwork. And dust-tight rain-proof type fittings shall conform to B.S. 4533-2.1 (1P63) or B.S. 4533-2.2 (1P63).

Splash-proof lighting fittings shall conform to B.S. 1P24 and be provided with Class 1 earthed metalwork.

Dust-proof and splash-proof fittings shall conform to 1P54 and be provided with Class 1 earthed metalwork.

Street light fittings shall conform to B.S. 1788 and the column shall be aluminum alloy conforming to B.S. 3989.

Control gear sets for fluorescent lamps and interior discharge lamp fittings.

The control gears sets shall be of high power factor type with automatic resetting thermal protector and be built-in the housing of the lighting fitttings or installed near by the appropriate lighting fittings only when directed on the drawings. The gear shall be manufactured strictly in accordance with the requirement of applicable safety code and of standard product of the manufacturer.

All control gears shall be provided with radio interference suppression device.

8.4 Fluorescent tube circuit installation:

Supply cables shall have current carrying capacity of not less than 125% of the load current at normal ambient temperatures. The size of the cables shall be increased accordingly for the higher ambient temperatures.

8.5 Lamps:

Straight or "U" shaped Bi-pin fluorescent tubes shall conform to B.S. 1853.

High pressure mercury vapor lamps shall conform to B.S. 3677. Low pressure sodium vapor lamps shall conform to B.S. 3767. Tungsten filament general service electric lamps shall conform to B.S. 161.

Dimension of screw lamp caps and lampholder shall conform to B.S. 555.

Byonet lamp-caps, lampholders and B.C. adapters shall conform to B.S. 52.

8.6 Controls:

All lighting system shall be controlled by the methods indicated on the drawings. Any better alternative method is suggested by the Contractor, such alternative shall be indicated on the shop drawing and submitted to the Engineer for approval.

Each area-lighting pole shall be provided with a rain-tight type 5 ampere trip rated circuit breaker to protect individual luminaire. The sub-circuit of outdoor lighting system shall be connected with the supply side terminals of the circuit breaker to feed neighboring area-lighting circuit consequently located.

Individual circuit of area-lighting circuit shall be connected with a circuit-breaker in the distribution board to be installed in the Power Building.

The area-lighting distribution board shall be consisting of minuature circuit-breakers and shall be connected with a earth-leakage circuit-breaker protected magnetic lighting contactor which shall be controlled by a astronomical dial controlled timer relay that shall be located in the Power Building.

9. SOCKET-OUTLETS SYSTEM

9.1 The Contractor shall furnish and install all socket-outlets system including wiring, distribution boards, and matching male plugs in accordance with the drawings.

9.2 In low-voltage single-phase A.C. or D.C. circuits, plugs and socket-outlets shall conform to the following table:

Type of plug and socket-outlet	Rating (amperes)	Appropriate B.S.
Fused plug and shuttered socket-outlets, 2-pole and earth, for A.C.	13 (with fuses rated at 3 & 13)	1363 (fuses to 1362)
Plugs (fused or non-fused) and socket-outlets, 2-pole and earth	2, 5, 15, 30	546 (fuses if any to 646)
Plugs (fused or non-fused) and socket-outlets, protected type, 2-pole with earthing contacts	5, 15, 30	196
Plugs and socket-outlets (theatre type)	15	1778
Plugs and socket-outlets (industrial type)	16, 32, 63, 125	4373

9.3 Plugs and socket-outlets for medium-voltage circuit shall comply with B.S. 4343.

9.4 Plugs and socket-outlets other than those complying with B.S. 1363, 546, 196, 1778 or 4343, may be used in low-voltage two-wire circuits:

(a) for the connection of electric clocks, provided that the plugs and socket-outlets are designed specifically for that purpose, and earth plug incorporates a fuse of rating not exceeding 3 amperes complying with B.S. 646 and B.S. 1362 as appropriate.

(b) for the connection of electric shavers, provided that the socket-outlets shall either be incorporate in a shaver supply unit complying with B.S. 3052 or, in rooms other than bath-rooms, be of a type complying with B.S. 4573.

9.5 Plugs incorporating capacitors for radio interference suppression shall comply with the appropriate British Standard, and types and maximum values of capacitors used shall be in accordance with the requirements of B.S. 613.

9.6 Cable couplers and connectors shall conform with B.S. 196, B.S. 1778, or B.S. 4343.

9.7 Lower current rating socket-outlet adapter to be used with the larger current circuit shall have approriate fuses. Socket-outlet adaptors intended for use with electric shavers shall incorporate with a fuse of rating not exceeding 3 amperes complying with B.S. 646 or B.S. 1362 as appropriate and shall be marked "FOR SHAVERS ONLY".

10. ELECTRICAL MOTOR CIRCUITS

10.1 General

10.1.1 The Contractor shall furnish and install electrical wiring system associating with motor starters, ancellary equipment, and distribution board for all motors as indicated on the drawings.

10.1.2 Where indicated on the drawings, magnetic motor starters in robust metal enclosures with push-buttons, pilot lights, red and green, manual resetting buttons shall be installed. The motor starters shall be provided with overcurrent and single phase failure operation protective device set at the rating of the motor connected with it. Where indicated on the drawing pushbutton station may be installed at the location apart from the starters. Where required the motor starters shall be provided with H.R.C. (high rupturing capacity) fused isolator or circuit-breaker having sufficient interrupting capacity within the starter case or at the adjacent of the starter.

10.1.3 Where indicated on the drawings, the Contractor shall furnish and install a centralised control centre of self-supporting, totally packaged steel type consisting of standard modular dimension units with swing doors as noted on the drawings. In order to avoid excessive temperature raise inside the control centre, the number of the module in one column shall not be more than that indicated on the drawing.

Bus shall be provided with colour distinction. Horizontal bus shall have full ampere capacity of tropical rating shown on the drawing. Vertical bus shall have enough ampere capacity of tropical rating to carry continuous load of the maximum allowance connecting load in on column. Both bus shall have sufficient rupturing capacity. The complete control centre shall contain main isolating mans of type shown on the drawing, sub-main moulded-case circuit-breaker, earth-leakage type shall be used where indicated on the drawing, and combination type motor control gears shall be provided with single phase failure protective device if circuit-breakers are not of motor protector equipped type. Each motor control gear shall be provided manual reset button on cover door, where required on the drawing pilot lights, 'hand-off-auto' change-over switch shall be provided. All motor control centres shall be factory wired internally. Only field wiring to be required shall be source and control wiring beyond main lugs, control wiring, and earth continuity wiring. All wiring shall be connected at lugs or terminal blocks, and all terminated cables shall be provided with terminal markers.

10.1.4 Motor control centre shall conform to applicable British Standard Specifications, and also all components and wiring devices and materials in use shall be strictly in accordance with relative British Standard Specifications.

10.1.5 The colour sample of control centre for outside and inside finishing shall be submitted to the Engineer for approval.

10.2 Section applying to all motors:

10.2.1 Power supplies shall be given at 415 volts 3 phase 50 cycles. Motor below one horse power may be connected to the single phase supply at 240 volts 50 cycles. A number of motors each above 70 H.P. shall be recommended that such motors should be connected to a supply at high voltage.

10.2.2 Where shown on the drawing, each motor up to 5 H.P. may be connected to the single phase supply. No single phase motor in excess of 5 H.P. shall be connected to the supply. Self-contained air-conditioner up to 1-1/2 tons capacity may be connected to a single phase supply, but where more than two such units are used, such units shall be so connected to the system that the load shall be balanced between two or three phases.

10.2.3 All single phase motors larger than 1-1/2 H.P. shall be provided with capacitors for maintaining the power factor at not lower than 80% throughout the normal working range of the motors.

10.2.4 Three phase motors not over 25 H.P. may be started "direct-on". Motors above 25 H.P. shall be provided with equipment to ensure that starting current does not exceed 120 amperes per line or twice full load current, whichever is the larger.

10.2.5 Where transformer sub-stations are installed in the immediate vicinity of the premises, starting current for three phase motors 100 amperes per line may be permitted.

10.2.6 All motors over 1 H.P. shall be provided with means for automatically disconnecting them from the electrical supply in the event for:

(a) failure of supply.

(b) serious voltage drop.

(c) flow of excess current.

10.2.7 All motors of 25 H.P. and above shall be also protected by automatic earth-leakage circuit-breaker or relay.

10.2.8 All motors shall be provided with means of isolation from the supply for purposes of adjustment and maintenance. Such means of isolation shall effectively interrupt the supply on all conductors.

10.2.9 All motors and control gear shall have their frames, cases and all metal parts not normally carrying current, effectively and continuously earthed. Each motor, starter, regulator and other component shall be separately connected to a main earth conductor which shall be directly connected at each end to the principal earth electrode or electrodes. Not less than two principal earth electrodes shall be installed, and these shall be interconnected by an underground run of cable.

The "Series" method of earthing one piece of equipment to another shall not be approved. The cross sectional area of the main earth conductor shall not less than a half of the phase conductor for the largest motor or other component circuit. The minimum size of the earth conductor shall not be smaller than 10 mm^2.

10.2.10 All motors and control gear shall comply with the relevant British Standard Specifications, including dimensional standards where these are applicable.

10.2.11 All motors, control gear and ancillary apparatus shall be capable of continuous and prolonged operation in ambient temperature as specified in other provision of these specifications.

10.2.12 All motors, control gear and ancillary apparatus shall be totally enclosed with or without forced ventilation or otherwise arranged to exclude dust in a proper manner. If installed in outside of the buildings all motors and equipment shall be capable of satisfactory operation during sand storm of several hours duration.

10.2.13 All three phase motors shall be provided with means of automatic protecting device for single phase operating. All overload trips of the thermal type shall be provided with automatic compensation for various in ambient temperatures between 32°F (0°C) and 175°F (79.4°C).

10.2.14 All motors, control gear and ancillary equipment shall be protected by a switch with H.R.C. fuses or circuit-breaker for shutting off supply during inspection and maintenance. Such disconnecting means may be integral with the control gear, or may be separately installed but shall be within view from the starter position. Where several starters are mounted in a panel, rack or bank each starter shall have a separate disconnect means. One main switch with H.R.C. fuses or main circuit-breaker shall be provided to cut the incoming supply to the whole panel or motor control centre.

10.2.15 Where starter control circuits and control apparatus (e.g. pushbuttons, limit switches, detectors, etc.) are energised by any auxiliary supply other than the main power circuit to the motor, the isolator shall incorporate auxiliary contacts to effectively isolate all poles or phases of such auxiliary supplies.

10.2.16 All motors, control gear and all ancillary apparatus (e.g., remote pushbuttons, pressure, float or limit switches, interlocks, relay, etc.) shall be of robust construction and shall have all windings, contacts, and current carrying and live parts and components insulated with Class B materials. In special locations approved by the Engineer in such case, motor insulated with Class E materials may be installed.

10.2.17 A clear schematic diagram of circuits and components contained in the case shall be firmaly fixed within the lid or cover of each starter, controller or cubicle.

10.2.18 Unless otherwise specified, motors and their control gear required for reversing duty, shall be capable of not less than 40 starts per hour. All contactors for motors on reversing duty, shall be so designed that it is impossible to close both forward and reverse contactors at the same time. Any mechanical interlocking to accomplish this shall be very robust, and, as far as possible, inherent in the design of the contactor.

10.2.19 All starters and pushbuttons shall be clearly labelled in Arabic and English stating machines they control, and the

function of the various buttons. Wards shall be indicated as "START AND STOP etc.". All Arabic designations shall be subject to the approval of the Engineer.

10.2.20 Stop pushbuttons shall have large mushroom heads and/or be coloured bright red. Start pushbuttons shall be shrouded to prevent accidental operation and be coloured green.

11. THREE PHASE WORK

11.1 General

In any premises where all or a part of the electrical load consists of lights, fans, and/or other single phase consuming devices, the provisions of the single phase specification shall apply to each separate pahse as if it was separate installation.

In any one room or otherwise will defined area not exceeding 100 sq. metres in area all single phase consuming devices shall be connected to the same phase of the supply unless otherwise specifically required by the Engineer.

In large halls and other situations where the load is to be divided between two or three phase whether for load balancing purpose or otherwise, no two single phase switches, fans, lights fuses, other equipment or accessories connected to different phases shall be mounted within 2 metres of each other unless they are so constructed or so marked and maintained that it is impossible for any person to expose live metal therein without first being aware that danger of shock between phases exist therein.

11.2 Bunching and segregation of conductors:

Where conductors or bunches of conductors are protected by metallic sheathing, installed in conduit, trunkings or ducts, the conductors of all phases and neutral, associated with any one circuit, shall be included in the same sheath, conduit, trunking, or duct.

Where conductors pass through the metallic case of any switch fuse, distribution board of other apparatus, or through any steel structure of building, etc. all phase conductors and the neutral associated with any circuit shall pass through the same hole or apperture in such case, or structure.

Where 240 volts loads are fed from a three phase and neutral distribution board no conduit shall contain the wiring fed from more than one phase.

Where circuits are bunched proceeding from the distribution board and have separated, they shall not be brought back again into any common conduit.

11.3 Socket outlets and plugs:

Socket outlets and plugs for use on more than one phase shall include a pin or other approved contact for the earth continuity connection which shall make contact before and break contact after all the phase connections and neutral connection where such is fitted. Where a pin for the neutral conductor is fitted, it shall make contact not later than and break contact not earlier than all the pins for the conductors.

The design of the socket and plug shall be such that the plug can not be inserted (even using appreciable force) in such a manner that the neutral and any phase conductors become wrongly connected to the supply.

All socket outlets and plugs of 15 amperes rating and larger shall be combined with a switch so interlocked with the plug that the circuit must be made or broken by insertion of the plug into or removal of it from the socket.

Where viewed from the direction in which the plug is inserted, all multi-phase socket outlets shall have the contact tubes so connected to the various supply leads that when read in order in a clockwise direction they shall be, Phase A, Phase B, Phase C, Neutral Earth. The phase being so arranged that they give standard rotation to a phase sequence indicator.

11.4 Isolators:

All motor and other electrical devices not connected to the supply by means of a socket outlet shall be provided with isolators which effectively disconnect all phases of the supply from the machine or apparatus and its control gear. Where a neutral conductor is presented a neutral link or special switch blade with close but does not open on operation of the isolator shall be provided. Such isolator may form part of the control gear if the incoming terminals and contacts are still covered by an insulated or an earthed barried when the main covers of the control gear are removed.

12. WIRES AND CABLES

12.1 General

Secondary cables shall have multi-stranded tinned copper conductors insulated with coloured polyvinyl chloride. The insulation of each line conductor shall be to the standard of the 600 volts grade of the Cable Makers Association in single, twin, or three core type as specified on the drawings. Wires and cables shall comply in all respect with the current British Standard Specifications covering polyvinyl chloride insulated.

No cable with a conductor smaller than 1.5 mm^2 shall be used in any circuit connected to the 240 volts supply. A maximum connected load on a 1.5 mm^2 cables circuit shall not be more than

1600 watts under normal conditions that any rating factors be applied.

Cables with conductors of 2.5 mm^2 or larger shall be used for circuits supplying socket outlets, and elsewhere as specified.

Where polyvinyl chloride or lead sheathed cables contain an earth continuity conductor within the same sheath, the earth conductor shall not be smaller than that specified below:

- with 1.5 mm^2 line conductors, 1.0 mm^2 earth conductor.

- with 4.0 mm^2 line conductors, 2.5 mm^2 earth conductor.

Current carrying capacity of wires and cables shall not exceed the value shown below:

Current Carrying Capacity of V.R.I. & P.V.C.

wires & cables

Single Core

Size of conductor mm^2	Two cables in one casing or conduit for single phase A.C. amps.	Three or four cables in one casing or conduit for balanced three phase A.C. amps.	Four cable in one casing or conduit for single phase A.C. amps.
1.5 sq.mm	7	6	6
2.5 "	12	11	10
4.0 "	19	17	15
6.0 "	22	19	17
10 "	31	28	25
16 "	36	33	29
25 "	52	48	44
50 "	67	61	54
70 "	110	96	-
120 "	155	140	-

Where more than 2 circuits are bunched in the same conduit the above current carrying capacity shall be applied with the following bunch factor ratings:

No. of circuits:	3	5
Rating factor :	0.6	0.5

All wires and cables shall be so installed that they are not themselves reliable to damage, nor to cause damage, injury or danger to other.

At all terminations of wires and cables, the insulation shall be neatly stripped without nicking the strands of the conductor.

The brading or outer sheathing of the wire or cables shall be stripped back not less than 7 mm further than the insulation and the conductor shall be tightly twisted and double back (where space is available in the terminal) before being clamped with pinching screw. Where two or more wires or cables are looped into the same terminal, their conductors shall be tightly twisted before being inserted into the terminal. In no case shall bare conductor be allowed to project beyond any insulated shrouding or mounting of a live terminal.

Cables connected in parallel shall be of the same type, size and length, to ensure proper division of the current.

12.2 Applicable B.S. for low-voltage and medium-voltage cables:

Every cable for use as fixed wiring operating at low or medium-voltage shall be selected from the following types and shall comply with the appropriate British Standard Specifications referred to below. In cables of every type, conductors shall be of copper unless otherwise specified on the drawing:

(a) Non-armoured P.V.C.-insulated cables (B.S. 6004, B.S. 6231 Type B or B.S. 6346)

(b) Armoured P.V.C.-insulated cables (B.S. 6346)

(c) Split-concentric copper-conductor P.V.C.-insulated cables (B.S. 4553)

(d) Cables insulated with valcanised rubber, butyl rubber, E.P. rubber, or silicon rubber (B.S. 6007)

(e) Impregnated-paper-insulated cables, lead-sheathed (B.S. 6480 Part 1)

(f) Mineral-insulated metal-sheathed cables (B.S. 6207, Part 1 Or Part 2)

(g) Cables for discharge-lamp installation (B.S. 559 in compliance with I.E.E. Regulations G15-16-17 and G25-26)

(h) Flexible cables & Flexible cords complying with I.E.E. Regulations B.4.

Busbars and busbar connections on switchboards shall comply with Regulation B.S. 159. This requirement does not apply to busbar trunking system.

Every flexible cables and flexible cords for use at low or medium-voltage shall conform to one of the follows:

(a) flexible cords insulated with P.V.C., valcanised rubber, butyl rubber, E.P. rubber, silicon rubber, or glass fibre (B.S. 6500)

(b) flexible cables insulated with valcanised rubber, butyl rubber, E.P. rubber, silicon rubber (B.S. 6007)

12.3 Flexible cords and cables:

No smaller than 0.75 mm^2 shall be used. Size of flexible cords and cables shall be such that the current normally carried by them shall not exceed the values shown as follows:

Current carrying capacity of flexible cords

Size of conductor mm^2	Current rating for single of three pahse A.C. amps.
0.075	3.4
1.0	6.9
1.5	10.0
2.5	14.0

Where apparatus requires to be earthed, flexible cables shall be provided with earthing conductor.

Conductors of flexible cable shall be colour distinctive in accorcance with other provision of these specifications.

Flexible cables and cords shall be so connected to portable or fixed apparatus, standard lamp, etc. that the earth conductor is connected to the frame of the apparatus and any single pole switches are so connected that they break the phase (red) conductor to the apparatus.

Tough rubber sheathed (TRS) or cab-type sheathed (CTS) type cables shall be used in lieu of flexible cables where situation requires rough handling.

Connection of flexible cords and cables to terminals of apparatus and accessories shall be in a similar manner to those wires and cables.

12.4 Joints and connections:

Joints shall be avoided in conductors of all sizes wherever possible.

In final sub-circuits and sub-circuits feeding two or more lights, switches, sockets and/or other accessories the loop in system of wiring employed.

Where joints are essential they shall be housed in purpose made boxes and/or be otherwise readily accessible for inspection throughout the life of the installation. Under no circumstances shall joints be drawn into conduits or positioned in the thickness of walls, ceilings or floors, etc. or behind plaster, tile or panel finishes, etc.

Joints in conductors not larger than 4.0 mm^2, shall be made by barrel type connectors with adequate pinching screws, and terminal blocks fixed to the junction box or other housing.

Joints in conductors larger than 4.0 mm^2 shall be made with approved clamps in approved housings and shall be to the satisfaction of the Engineer.

All sharp edges and ends of conductors, and strands shall be removed and insulation shall be applied with layers of insulation tapes.

Joints in earth continuity conductors, earth lead, etc. shall be made in a similar manner to those in current carrying conductors. The strands of the various coductors and/or lead shall be adequately cleaned, and twisted together before being inserted in a barrel connector or before being soldered.

The resistance of a joined conductor in all cases shall be the same with the resistance of unjointed conductors.

13. CONDUITS & CONDUIT FITTINGS

13.1 Conduits to be used in this contract shall be of heavy gauge galvanized steel or approved type P.V.C. type. "Bergman" tube shall not be used.

13.2 Steel conduits and fittings for use therewith shall comply with B.S. 4568, Part 1 and Part 2. And B.S. 31 shall be applicable to fittings.

13.3 P.V.C. conduits and fittings for use therewith shall comply with B.S- 4607, Part 1 or Part 2, as applicable.

13.4 The internal radius of every bend shall be such as to allow compliance with the appropriate values stated in Table B.1M of I.E.E. Regulations for bends in cables and, in addition, the inner radius of bend shall not be less than 2.5 times the outside diametre of conduit.

13.5 The use of solid (non-inspection) conduit elbows or tees shall be located at the end of conduits immediately behind lighting fittings, outlet box or accessory of the inspection type, or be restricted to one solid elbow located at a position not more than 500 mm from a readily accessible outlet box in a conduit run, and not more than 10 metres between two outlet points provided that all other bends in the conduit run are not more than the equivalent of right angle.

13.6 Total cross-sectional area of cables in conduit shall not exceed 40% of the cross-sectional area of the conduit.

13.7 Steel conduit shall not be installed underfloor or underground unless such conduit be coated with two heavy coats of hot bitumen or red lead oxide. Only P.V.C. or alminum conduit can

burried underfloor or underground, with proper reinforcing encasement where required.

13.8 P.V.C. and metal conduit shall not both be installed in the same conduit run unless such installation is unavoidable. In such case both types conduits shall be connected with appropriate connecting fittings.

13.9 P.V.C. conduit shall not be used at where mechanical strength be applied directly on conduit, or in exposed location at the height of conduit is not less than 2.43 metres from the finished grade.

13.10 The bores of all conduits shall be smooth and free from projection and/or sharp edges which might injure the wires or prevent them being drawn in. The internal edges of the bends of all conduits shall be radiused or chamfered before assembly into position.

13.11 All runs of conduit shall be assembled completely and firmly, attached to the structure of the building before any wires are drawn in. All wires shall be drawn in through the covers of inspection and other fittings installed for the purpose. The running joints for drawing in of wires and cables shall not be permitted.

13.12 Conduit system shall be readily accessible for inspection or rewiring purpose throughout the life of installation.

13.13 Where conduit and/or conduit fittings are attached to switch and/or fuse casings, steel or cast iron boxes or other equipment, the material of the case or box shall be tapped for a depth of not less than 10 mm or smooth bore (male) brass bushes and flange coupling shall be used.

13.14 P.V.C. rigid conduit shall be jointed to fittings or boxes made of a plastic material specifically for the purpose, such jointing secured by locking ring. No cement is required, except that it is recommended in dump situation.

13.15 P.V.C. conduits shall not be used where the ambient temperature would be below 15°C, or above 65°C.

13.16 Where a P.V.C. outlet box is used for the suspension of a lighting fitting, care shall be taken to ensure that the temperature of box does not exceed 60°C. The mass suspended from the box shall not exceed 3 kg.

13.17 Where metallic conduit exposed to weather or installed in damp location, all conduits and fittings shall be of corrosion-proof type.

13.18 All runs of conduit shall be truely vertical or horizontal except where the architectural features of the building demand otherwise.

13.19 Except where provision is made for fastening a box or other conduit fitting directly to the building structure, and such fastening is made, conduit shall be saddled to the structure of building within 150 mm of each terminal box, angle box, bend, tee or other conduit fitting and at interval not greater than 15. metres. Coupling and through type draw-in boxes shall be counted as part of a straight run of conduit.

13.20 Conduits for Category 3 circuits shall have colour of orange or painted with orange colour enamel throughout in the installation.

13.21 Where conduits are buried in walls or in the ceiling slabs of the building, all branch switches, sockets, ceiling roses, etc. shall be housed in purpose made galvanised or sheradised boxes and all switch plates, socket plates and accessories shall be installed flush with the plaster finishing.

13.22 Where conduits are run on the surface of walls or ceiling of the building, all branch switches, sockets, ceiling roses, and fan regulators may be mounted on hardwood or teak blocks or boxes provided the earth continuity is maintained between conduit and metal casing of accessory. All such mounting blocks shall be securely fixed to the structure of the building in such manner that they can not rotate or rock throughout the life of the installation. Block shall be painted with the same colour paint as the surrounding walls.

14. FLEXIBLE METAL CONDUITS

Flexible metal conduits and fittings shall comply in all respect with B.S. 731, Part 1. Flexible P.V.C. conduit shall comply with B.S. 4607, Part 3 and fittings for use therewith shall comply with B.S. 4607, Part 1 or Part 2, as appropriate.

Flexible metal conduit shall not be used as the sole means of providing earth continuity and separate conductor complying with the appropriate requirements of the I.E.E. Regulations D.27-30 shall be provided for every part of a system formed by such conduit.

Where any cables carried in conduit have to be connected to an electric motor or other apparatus subject to adjustment of position or to vibration, connection shall be made by flexible conduit of the same internal diametre as the main conduit, and not less than 0.30 mm, but not more than 1.5 metres.

Flexible conduit shall be secured at not more than 0.15 mm apart from the both ends of flexible conduit.

15. FINAL SUB-CIRCUIT INSTALLATIONS

15.1 General

Final sub-circuit is an outgoing connected to a distribution board and intended to supply electricity to electrical apparatus, either directly or through socket-outlets of fused of excess-current protected spur-boxes.

The wiring of each sub-circuit shall be electrically separated from that of every other final sub-circuit. For easy disconnection of each final sub-circuit for testing, the neutral conductors shall be connected at the distribution board in the same order as that in which the live conductors are connected to the circuit-breakers.

A final sub-circuit having a rating exceeding 15 amperes shall not supply more than one point except specially permitted in the I.E.E. Regulations. And, above stated limitation may not be necesaary to apply the follows:

(a) a cooker control unit incorporating a socket-outlet.

(b) a luminaire (lighting fitting) track system complying with B.S. 4533 provided that indidividual luminaires are suitably against excess-current.

Not more than five lighting circuits or three socket circuits shall be bunched in the same conduit.

Circuit fed from different distribution boards or through different isolater shall not be bunched in the conduit.

Bunch rating factor shall be applied to the current carrying capacity of conductors in the same conduit as stipulated in the other Provision of these Specifications.

The minimum size of the conductors shall not be smaller than the sizes shown on the drawings, or specified in these specifications.

15.2 Lighting final sub-circuit:

15.2.1 In non-domestic installations final lighting sub-circuit shall not be rated nore than 15 amperes.

15.2.2 When wiring in installation with P.V.C. covered cables in conduits or trunkings, joints shall be avoided as far as possible, and the loop-in system shall be adopted. Wiring in conduit, the two lengths of cable forming the loop shall be threaded in separately and the junction shall be made at the switch, lighting fitting or other terminal.

15.2.3 The earth-continuity conductor of a circuit shall not necessary to be forming a loop system. The earth-continuity conductor per a circuit shall be installed in throughout

every conduit system and it shall be connected only at the fittings and switches. The colour of insulation material of the earth-continuity conductor shall be green.

15.2.4 All local or branch switches shall be of fully capacity of designated amperage shown on the drawings and shall have insulated dollies and covers. At the switch positions the conduit must be terminated with a box.

15.2.5 Unless otherwise specified on the drawings, all local and/or branch switches shall be mounted with the dollies 1.37 metres above the finished floor level. Where several switches are mounted two horizontal rows, the lowest row shall have dollies 1.37 metres above the finished floor level. Unless prevented by the swing of the door, all switches shall be mounted inside the room, except in the bathroom where the switch shall be installed outside of the room, on the side of the door where the catch or lock is situated, the nearest switch being approximately 0.15 metres from the door frame.

15.2.6 In kitchens and other situations switches shall be mounted within 2 metres of any taps, basin, sink or metal draining boards, or any pipe work connected thereto if such pipe work could be touched while touching the switch.

15.2.7 All one way tumbler switches (both single and double pole) shall be so mounted that the dolly is UP when the switch is in the "OFF" position.

15.2.8 All single pole switches shall be so connected that they control the phase lead to the light or other consuming devices.

15.2.9 All lampholders shall be of the all insulated pattern, and if not separately and firmly attached to a bracket, conduit or block, shall have a substantial cord grip with the flexible wire so connected that no pull due to the weight of the holder, lamp shade or fitting or pull on flexible can transmitted to the terminals.

15.2.10 In bathrooms, kitchens, and other places where water is regularly used, no lampholder within 2.45 metres shall be installed within 2 metres of any taps, basin or sink unless it and the lamp are totally enclosed in a fitting of insulated construction and the lampholder is of the heavy duty porcelain type. Such fittings shall be f mounted on a wall directly.

15.2.11 The screw cap of the lampholder shall be always connected to the neutral conductor.

15.2.12 Every switch not specifically designed to break an inductive load of its full rated capacity shall, if used to control a discharge-lighting, have a current rating of not less than

twice the total steady current which it is required to carry or, if used to control filament lighting and discharge lighting, have a current rating of not less than the sum of the current flowing in the filament lamps and twice the total steady current flowing in the electrical discharge lamps.

15.2.13 Circuits shall be capable of carrying the total steady current, viz. that of the lamps and any associated gear and also their harmonic currents. Where more exact is not available, the demand in volt-amperes may be the rated lamp watts multiplied by not less than 1.8. The neutral conductor in every discharge-lighting circuit shall have a cross-sectional area not less than that of the phase conductors.

15.2.14 Every inductor and high-reactance transformer shall be installed as near as is practicable to its associated electric discharge-lamp.

15.2.15 Lampholders shall not be connected to circuits having excess-current protection of rating the following:

Type of lampholder (as designated in B.S. 52, B.S. 98 and B.S. 1875)	Maximum rating of fuse or miniature circuit-breaker protecting the circuit (amp.)
Small byonet-type (B.15)	5
Small Edison-type screw (E.14)	5
Byonet-type (B.22)	15
Bi-pin type	15

15.3 Socket-outlets final sub-circuit:

Unless otherwise specified on the drawings, socket-outlets shall be of the 13 ampere three pin flat pin type with shuttered line sockets. The earth contacts of each socket shall be effectively connected to the earth continuing conductor and the neutral conductors shall be connected to the correct sockets, viz:

When viewed from the front, in its final mounted position the EARTH socket shall be below at the top, the NEUTRAL socket shall be below to the left, and the PHASE (OR LINE) socket shall be below to the right. The proper connections to ensure this are indicated by letters and colours adjacent to the pinching screw terminals.

No socket outlet shall be mounted in any bathroom, except shaver's socket which is combined with enclosed lighting fitting.

Two socket outlets may be connected to a circuit wired with 2.5 mm^2 cable protected by a fuse not greater than 15 amperes current carrying capacity.

Ten socket outlets may be connected to a circuit subject to the following provisions:

(a) The circuit shall consist of ring of 2.5 mm^2 cables looped from the last socket back to the distribution board. No more than two conductors shall be connected into one terminal of any socket.

The total floor area served by the socket on any one ring shall not exceed 100 sq. metres.

The total load exceeding more than 6 KW shall not be connected on ring circuit.

Not more than two sockets may be connected on a spur from the ring.

The total current rating of apparatus to connected to any one circuit shall not exceed 15 metres. The number of socket outlets connected to the circuit shall be reduced by one for each so that the total current shall not exceed 15 amperes.

All plugs supplied for use with socket outlets shall conform to B.S. 1363 and shall be fitted with 3 amperes fuse, unless the apparatus connected to the plug normally takes a larger current with a 7 amperes fuse may be fitted.

Plugs shall be connected to flexible conduit in accordance with the applicable provisions in these specifications.

Fuse or excess-current protection shal not be more than 30 amperes for a ring circuit.

SECTION 15D

EMERGENCY ELECTRIC POWER GENERATING SYSTEM

1. GENERAL

In order to back-up the power system in the premises in case of the stoppage of the commercial power service is taken place either by accidental power failure or the periodical maintenance service on the primary service lines, an emergency electrical power generating system shall be completed the contractor as indicated on the drawing. The system shall consist of the following equipment and all necessary equipment of devices be required by the system:

(a) Generating Plant.

(b) Engine starting system.

(c) Automatic engine starting and power change-over switchgear.

(d) Fue oil storage and transferring system.

(e) Engine cooling system.

(f) Generator room ventilating system.

2. EQUIPMENT

The Contractor shall secure for the purchaser a stand-by generator set of the latest commercial type and design as specified herein. All materials, and equipment, and parts comprising the units specified herein, shall be new and unused, of current manufacturer and of highest grade.
The engine, generator and all major items of auxiliary equipment shall be manufactured by manufacturers currently engaging in the production of such equipment. The unit shall be factory assembled, and tested by the engine manufacturer and shipped to the project site by his authorized dealer having a parts and service facility in the area.
Equipment furnished under this section of the specifications shall be guaranteed against defective parts or workmanship under terms of the manufacturer's and dealer's standard warranty.
The generator set shall receive the manufacturer's standard factory load testing. Prior to acceptance of the installation, equipment shall be tested to show it is free of any defects and will start automatically and be subject to full load test, or that load which is available at the project site.

On completion of the installation, start-up shall be performed by a factory-trained dealer service representative. Operating and installation book written in both English and Arabic shall be supplied upon delivery of the unit and procedures explained to operating personnel.

The tenderer shall furnish information showing manufacturers' model numbers, dimensions and weights for the generator set, and major auxiliary equipment. Proposed deviations from the specifications shall be stated in the tender document. The successful tenderer shall submit copies of pertinent drawings and wiring diagrams for approval.

3. GENERATOR SET CHARACTERISTICS

Acceptable unit shall have sufficient capability of the capacity to supply sufficient electrical service in the circumstances to be encountered at the project site.

Rating at 1500 RPM

Standby KW with fan : 260 KW

Standby KVA with fan : 325 KVA

Power factor : 80%

Frequency : 50 HZ

The standby KW capacity shall be for 10 hours electrical service during interruption of the normal utility source.
The rating must be substantiated by manufacturer's standard published curves. Special ratings or maximum ratings are not acceptable.
The generator out put voltage shall be 3 phase 4 wire 240/415 volts.

4. ENGINE

The engine shall be turbocharged-aftercooled type four-stroke cycle compression ignition diesel. It shall meet specifications when operating on No.2 domestic burner oil (ASTM D396). Diesel engine requiring premium fuels will not be considered. The engine shall be equipped with fuel, lube oil, and intake air filters; lube oil coolers, fuel transfer pump, fuel priming pump, and other necessary equipment. The engine governor shall maintain frequency regulation not exceed 3% (1.5 HZ) from no load to full rated load.
The unit shall be mounted on a structural steel sub-base and shall be provided with suitable vibration isolators. Safety shut-offs for high water temperature, low oil pressure, overspeed, and engine overcrank shall be provided.

5. GENERATOR

The generator shall be a three-phase, 50 HZ, single bearing, synchronous type with brushless exciter and be built to British standards. Class F insulation shall be used on the stator and rotor, and both shall be further protected with 100% epoxy impregnation and an overcoat of resilent insulating materials to reduce possible fungus and/or abrasion deterioration. Generator shall incorporate reactive droop compensation for parallel operation and include a thermal protector for generator protection against low factor loads. A generator mounted volts per Hertz type regulator shall be provided to match the characteristics of the generator and engine. Voltage regulation shall be ±2% from no load to full rated load. Readily accessible voltage droop, voltage level and voltage gain controls shall be provided. Voltage level adjustment shall be ±5%. The solid state regulator module shall be shock-resistant mounted and epoxy encapsulated for protection against vibration and atmospheric deterioration.

6. COOLING SYSTEM

An engine-mounted radiator with blower type fan shall be sized to maintain safe operation at 53 degree C maximum ambient temperature. The radiator shall be equipped for a duct adapter flange. Air flow restriction from the radiator shall not exceed 125 mm H_2O. The Contractor shall provide duct work with flexible connection between radiator duct flange and exhaust damper.
The installing Contractor shall provide motorized intake air and radiator exhaust air dampers mounted in wall openings as shown on the drawings. The damper shall open automatically when engine starts, close when engine stops.
Intake damper shall be sized and located to provide sufficient intake air for engine combustion, ventilating air, and to provide required air flow through the radiator. City water shall be used as coolant.

7. FUEL SYSTEM

An underground fuel storage tank, gauges, and valves, shall be supplied and installed by the installing contractor in accordance with the drawings.
A 1000 litres floor standing day tank unit shall be furnished and installed by the installation contractor. The tank shall incorporated threaded pipe connections, 240 volts a.c. suction pump, float switch, fuel gauge, and mounting brackets. Flexible fuel connections at engine shall be provided.
An engine-mounted fuel filter, fuel pressure gauge, and engine fuel priming pump shall be provided.

8. EXHAUST SYSTEM

Provide a critical or residential type silencer including flexible exhaust fitting for remote mounting, properly sized and installed, according to the manufacturer's recommendation. Mounting shall be provided by the installing contractor as shown on the drawings. Silencer shall be mounted so that its weight is not supported by the engine. Exhaust pipe size shall be sufficient to ensure that measured exhaust back pressure does not exceed the maximum limitations specified by the generator manufacturer.
The muffler and all indoor exhaust piping shall be lagged by the installing contractor to maintain a surface temperature not to exceed 66 degree C. The insulation shall be installed so that it does not interfere with the functioning of the flexible exhaust fitting.

9. AUTOMATIC STARTING SYSTEM

Starting motor a 24 volts d.c. electric system with positive engagement drive shall be furnished.
Fully automatic generator set start-stop controls in the generator control panel shall be provided. Controls shall provide shutdown for low oil pressure, high water temperature, overspeed, overcrank, and auxiliary contact for activating accessory items. Controls shall include a 30 second single cranking cycle limit with lockout.
A unit mounted thermal circulation type water heater shall be furnished to maintain engine jacket water to 32.2 degree C in ambient temperature of -1.11 degree C. The heater shall be single phase, 50 HZ, 240 volts.
A 24 volts Nickel Cadmium storage battery set of the heavy-duty diesel engine starting type shall be provided. The battery set shall be of sufficient capacity to provide for one and one half minutes total cranking time without recharging and will be rated no less than 170 amp-hours. A battery rack and necessary cables and clamps shall be provided.
A current limitting battery charger shall be furnished to automatically recharge batteries. The charger shall float at 1.41 volts per cell and equalize at 1.52 volts per cell. It shall include overload protection, silicon diode full wave rectifiers, voltage surge suppressors, d.c. ammeter, and fused a.c. input. a.c. input voltage shall be single phase 240 volts. Amperage output shall be no less than 5 amperes..

10. GENERATOR CONTROL PANEL

A generator mounted metal encased type vibration isolated dead front control panel shall be provided.

The panel shall contain, but not limitted to, the following equipment:

Voltmeter 0-600 volts, 2% accuracy

Ammeter, 0-800 amperes, 2% accuracy

Ammeter/Voltmeter Phase selector switch

Frequency meter

Automatic starting controls

Panel illumination lights and switch

Voltage level adjustment rheostat

Engine oil pressure gauge

Dry contacts for remote alarm wired to terminal strips

Faultindicators for low oil pressure, high water temperature, overspeed and overcrank

Four position function switch ; "auto", "manual", "off/reset", and "stop".

11. MAIN LINE CIRCUIT BREAKER

A generator mounted main line moulded case circuit-breaker rated 500 ampere trip shall be installed as a load circuit interrupting and protection device. It shall operate both manually for normal switching function and automatically during overload and short circuit conditions.

The trip unit for each pole shall have elements providing inverse time delay during overload conditions and instantaneous magnetic tripping for short circuit protection. The circuit breaker shall meet the British Standard Specifications.

12. AUTOMATIC CHANGEOVER SWITCH

An automatic changeover switch, 3-phase, 50 HZ, 3 pole with solid neutral and earthing bus for voltage specified herein and for the current rating indicated on the drawings shall be provided.

The changeover switch shall be equipped with the following accessories:

Time delay - nominal 1 to 3 second on changeover to emergency

Time delay-adjustable 2 to 25 minutes on re-changeover with 5 minutes unloaded running time.

Voltage & frequency lockout relay.

Differential protection three-phase-dropout at 70% and pickup at 90% voltage.

Test Switch.

Engine starting contact.

Two auxiliary contacts - close on emergency, close on normal.

13. OPERATIONAL AND MAINTENANCE MANUALS

The Contractor shall submit to the Engineer 5 copies of operational and maintenance manuals in English prepared by the generator manufacturer.

14. UNDERGROUND FUEL STORAGE TANK

(a) The contractor shall furnish and install a prefabricated underground fuel storage tank and necessary piping suitable for storing and transfering of diesel oil to be used by the emergency generator which shall be installed in the sub-station building as indicated on the drawing.

(b) The location of the tank shown on the drawing is for reference to the contractor, the contractor shall verify the actual construction site and shall submit the shop drawing which indicate the actual size of tank and pipes to be recommended by the generator manufacturer who will be the supplier of the generator.

(c) Excavation of the earth shall be carefully carried out considering the existing earth conditions. If should there be any obstruction, the contractor shall inform the situation to the Engineer to resolve it.

(d) The underground fuel tank shall be fabricated with hot-rolled steel of its thickness shall be not less than 5mm, and the inside and outside of tank shall be treated in accordance with the requirement by the applicable safety regulations, and tested and proven tight against leakes at test pressure of 0.35 kg/cm^2. All opening shall be threaded.

(e) All seams shall be by welding. There shall be no usage of galvanised lines, fittings or fuel tanks in the fuel system.

15. PIPE LINES AND ANCILLARY EQUIPMENT

The underground tank shall be provided with the following pipes and ancillary equipment, as a complete system.

(a) Fill pipe.
(b) Vent pipe.
(c) Lowe level alarm switch or level metre.
(d) Supply and return pipe lines to be connected with the day tank via a fuel transfer pump.

16. SOLENOID VALVE

A solenoid valve interlocked with electrical system shall be installed on supply line pipe.

17. All connections between the engine and fuel pipes shall be connected by means of flexible pipes.

18. The underground fuel tank shall be earthed by means of made earthing rod/s.

SECTION 15E

MANUAL FIRE EVACUATION SYSTEM

1. GENERAL

The Contractor shall furnish and install menual fire evacuation system, where indicated on the drawings.

The system shall consist of the following equipment and devices.

(1) Manual fire evacuation control board.

(2) Alarm bells.

(3) Manual alarm actuation stations.

(4) Loating lights.

(5) Conduit and wiring system.

2. EQUIPMENT

The manual fire evacuation control board shall be provided with annunciator windows to be lighted upon actuation of manual alarm actuation station. The annunciator windows shall be provided with red acrylic plate with white painted engravings indicating room or areal nomenclature both in Arabic and English.

The letter height shall be approximately 5mm and stroke shall be at least 1.2mm.

The control board shall be served by 240 volts 50 HZ, and also be provided with self contained d.c. power pack consisting of alkaline battery and battery charger. Voltage of battery shall be 24 volts and shall have enough current capacity to supply the power to the system for 10 hours after outage of commercial electric system. The cabinet shall be robust sheet steel made and coloured with red baked enamel.

The alarm bells shall be normally 150mm in diameter and rated for 24 volts d.c. Where used in outdoor the bells shall be so constructed that can be suitable for installation under raining and sant-storming weather conditions. Colour of bells shall be red.

The manual alarm actuation stations shall be constructed with die formed steel or aluminium and of break glass type. Push button mechanism shall be of maintained contact type and releasing of the actuation shall be made only by the authorized person who has the resetting key. Where installed in outdoor, the station shall be of rain-and-dust tight construction.

Where indicated on the drawing, surface or flush wall mounted incandescent lighting fitting made for purpose shall be installed above the manual alarm actuation station, combining with location indication sign board. The fitting shall be with a red colour plastic lens of the size as indicated on the drawings. The wattage of lamp shall be 2 watts and fed by a independent conduit wiring system derived from the emergency board served by the 24 volts emergency batteries.

The conduit and wiring installations shall be completed in accordance with the manner recommended in other part of these specifications, however the wiring for this system shall be completely independent with all other systems, except for the wiring between control board and telephone terminal cabinet to perform the connection of the system with the local fire station.

SECTION 15F

TELEPHONE CONDUIT SYSTEM

The Contractor shall furnish and install a empty conduit system for public telephone system in each building as recommended by the P.T.T., and in accordance with the drawings.

The each building shall be provided with underground conduit stubout and main telephone terminal cabinet for the public telephone system be provided by other.

Telephone outlet boxes with nonmetallic cover plate, these conduit system shall not be combined with all other electrical system of any category.

All conduit system shall be provided with a 1mmø galvanized steel fish wire for pulling of communication cables.

Telephone terminal cabinets shall be of proper size with proper terminal block and wire spaces around installed terminal block.

Introduction and installation of telephone cables, and furnishing, connection, and installation of equipment shall be completed by other.

SECTION 15G

CONTROL WIRING OF PUMPS AND BLOWERS

1. GENERAL

The contractor shall complete all control wiring for the pumps and blower system in accordance with the control diagram and sequence of operations indicated on the drawings.

2. CONTROL SYSTEM

The electric motors pertaining to those systems shall be manually or automatically operated depend on the sequences indicated on the drawings.

(a) Manual control

The manual control shall be accomplished by the changeover switch which shall be installed on the cover of individual motor starter or separately encased in a robust metallic enclosure, as indicated on the drawings.

(b) Automatic control

The automatic control shall be accomplished by means of floatless electrodes type liquid level controllers as indicated on the drawings. The Electrodes shall be shrouded by robust factory made box and attached firmly on the surface of the container of which contained liquid levels to be controlled. The relays shall be completely dustfree capsulate type and assembled in a robust metallic cabinet, and the diagrams and control sequences written in Arabic and English shall be submitted to the Engineer after the completion of the work.

3. TEST

The contractor shall carry out, under the supervision of the Engineer, the test of the systematic operations. Should drastic conflict between mechanical and electrical control system be found the contractor shall report the fact to the Engineer. In case the changes be necessary the contractor shall submit the shop drawing showing the necessary changes for the approval.

4. COORDINATION TO MECHANICAL CONTRACTOR

It shall be noted that the contractor shall realize that it may be required the connections between electrical relays and mechanical devices indicated on mechanical drawings, in order to avoid the conflict the electrical contractor shall find out the requirement of the mechanical systems control contacts prior to the purchasing

of the control devices. Such relays shall have adequate numbers of contacts which can accomplish the required control sequences stated on the electrical and mechanical drawings.

5. WIRING

The control wiring shall be installed and tested as well as other electrical wiring defined in these specifications.

6. EARTHING

All low voltage control devices to be enclosed or required on metallic structures shall be earthed.