10500 PIPE WORKS

10501 General

10501.1 Scope of Work

This Section prescribes pipe materials, valves and their installations for the pipelaying works for raw water transmission pipe, interconnection pipe in the treatment works yard, pipes in filter pipe gallery and associated pipes in each structure.

The Contractor shall be responsible for ensuring that the pipes, fittings and valves laid or installed on each section of the work are of the standard and pressure classifications specified as appropriate to the circumstances, and are manufactured of the specified materials.

10501.2 Handling, Transporting and Storing Pipe Materials

Pipes, fittings, specials and other materials shall be handled, moved, lifted or lowered with the least possible impact. Handling equipment shall be of approved type. In slinging pipes only flat slings shall be used and the use of chain slings, hooks or other devices working on scissors or grab principles shall not be permitted. Pipes shall be slung from two or more points as the PMO/Engineer may direct and the slinging, lifting and lowering shall be in the hands of a competent and experienced man.

Subject to the requirements of inspection before acceptance, protective bolsters, caps or discs on the ends of flanges of pipes or specials shall not be removed until the pipes or specials are about to be lowered into the trench. Every precaution shall be taken to prevent damage to internal linings or external coatings.

Pipes in storage shall be supported clear of the ground on approved supports and adequately braced to prevent rolling. They shall not be more than four tiers high unless otherwise approved by the PMO/Engineer.

Materials of different classification shall be stored separately.

All pipes and associated materials shall at all times be protected from sun and weather to

the satisfaction of the PMO/Engineer.

No valves shall be lifted by the spindle. No valves, fittings or specials shall be stacked more than one tier high without the approval by the PMO/Engineer, and they shall not be stored in a dirty place or condition and shall not be allowed to become embedded in earth, sand, stone, aggregate, water, fuel or any other deleterious matter.

Great care shall be taken at all times to keep the faces and seats of all valves clean and free from dirt and grit of any kind. No valve shall be closed without at first wiping the faces with a clean cloth. The cavity beneath the valve doors shall be thoroughly cleaned by hand. In the event of accidental spilling of bitumen, cement or other matter, they shall be either dissolved or carefully removed by methods do not involve scraping of the faces.

Valves and their ancillary equipment shall be protected before and after erection against collapse of earthwork, falls of materials, concrete and cement droppings, wood and other matter.

Shortly before laying or fixing any valve, pipe or fittings the Contractor shall in the presence of the PMO/Engineer or PMO/Engineer's representative carefully examine each valve, pipe and fittings to ascertain damage or defect occasioned to the valves, pipes and fittings during loading, unloading, handling, storage and transportation. All damage and defects revealed by his examination shall be repaired and remedied by the Contractor.

10502 Pipe Materials

10502.1 Ductile Iron Pipe

(1) Requirement

Ductile iron pipe and fittings to be furnished shall comply with the requirements of :

- ISO 2531 - 1979	Ductile Iron Pipes, Fittings and Accessaries for Pressure Pipeline
- BS 4772 - 1980	Specification for Ductile Iron Pipes and Fittings

- JIS G 5526 - 1982 Ductile Iron Pipe

- JIS G 5527 - 1982 Ductile Iron Pipe Fittings

(2) Joint Type

All joints shall be of push-in type unless otherwise shown on the Drawing and specified in the Bill of Quantities. The push-in joint shall have weights and dimensions of socket and plain end in accordance with the JIS G 5526 or manufacturer's standard design.

(3) Coating and Lining

Outside coating of pipes and fittings shall be non-tar epoxy resin coating or manufacturer's standard. Inside lining of pipes shall be cement mortar lining which shall be in accordance with ISO 4179 - 1985 Centrifugal Cement Mortar Lining, BS - 4772 Appendix C Specification for Cement Mortar Lining and JIS A 5314 - 1984 Mortar Lining for Ductile Iron Pipe, or other standard approved equivalent. Inside lining for fittings shall be applied to the same as the outside coating.

(4) Puddle Flange

Pipes passing through water retaining walls and floors shall be equipped with puddle flange on the outside of the pipes as shown on the Drawings.

10502.2 Steel Pipe

(1) Requirement

Steel pipes and fittings, which are to be used for the piping in the filter pipe gallery, pressure piping in the sedimentation and associated pipes in the elevated tank, shall comply with the requirement of :

- ISO 559 - 1991 Steel Tube for Water and Sewage

- BS 534 - 1981 Steel Pipes and Specials for Water and Sewage

- JIS G 3442 - 1966 Galvanized Steel Pipes with Water Service

- JIS G 3452 - 1984 Carbon Steel pipes for Ordinary Piping

- JIS B 2301 - 1988 Screwed Type Malleable Cast Iron Pipe Fittings

- JIS B 2311 - 1986 Steel Butt - Welding Pipe Fittings for Ordinary Use

or other standard approved equivalent.

(2) Joint Type

Joints for pipes and fittings shall be either flanged, slip-on-type coupling, or welded or screwed as shown on the Drawings.

(3) Coating and Lining

Pipes and fittings shall be coated externally with an approved non-toxic bituminous composition except parts to be encased in concrete and pipe gallery. Pipes and fittings shall be coated internally with an approved bituminous composition.

(4) Puddle Flange

Pipes passing through water retaining walls and floors shall be equipped with puddle flange on the outside of the pipes as shown on the Drawings.

(5) Handling in Pipelaying Work

If required, the ends of the pipe shall have wooden stiffeners installed inside the pipe at quarter points at both ends of the pipe. This blocking shall remain inside the pipe until the pipe has been installed. The Contractor shall prevent any fires from being made inside or adjacent to the pipe. While the pipe is stored on site the pipe sections shall be kept free of any objects being stored inside and the larger diameter pipes shall not be occupied by workmen for any purpose. Stacking of pipe will be allowed only if blocking is provided between pipes.

All field cutting and mitering of the pipe shall be maintained. When such cutting is

required it shall be done by a suitable cutting machine, leaving a smooth cut at right angles to the axis of the pipe. Care shall be taken not to damage the coating or lining of the pipe.

10502.3 Polyethylene (PE) Pipe

(1) Requirement

High density polyethylene (PE) pipes under the working pressure of 68.7 MPa shall be used for underground pipes for supplying the plant water less than 100 mm in inside diameter and chemical dosing pipelines, and comply with the following standards for requirements on the materials and dimension :

- ISO 161/1 - 1978	Thermoplastic pipes for the transport of fluids - Nominal outside diameter and nominal pressure, Part 1 - metric series
- ISO 1167 - 1973	Plastic pipes for transport of fluids - Dimension of the resistance to internal pressure
- ISO 3607 - 1977	Polyethylene (PE) pipes - Tolerance on outside diameter and thickness
- BS 1972 - 1969	Specification for polyethylene pipe (Type 32) for above ground use for cold water services
- BS 3284 - 1967	Specification for polyethylene pipe (Type 50) for cold water services
- BS 6572 - 1985	Specification for blue polyethylene pipes up to size 63 for below ground use for potable water
- JIS K 6761 - 1979	Polyethylene pipes for general purpose
- JIS K 6762 - 1977	Polyethylene pipes for water works services

The pipe shall be supplied by the manufacturer in coil having a maximum length of

100 m. The pipes shall be coiled at a temperature inferior to 30 degrees C and the minimum permissible ratio between the radius of coiling and the external diameter of the pipe shall be 15.

(2) Joint Type

The pipes shall be jointed by means of electrowelded joints or polyethylene sleeve joint with the solvent cement. The connection and fittings shall have a nominal pressure rating identical to the polyethylene pipe on which they shall be mounted and they shall fit the same pipe exactly.

The connection with ductile iron pipe or steel pipe shall be done with flange joint or metallic connections. The metallic connections shall be made of copper alloy and they shall comply with the requirement of the following standards or equal equivalent of the manufacturer's standard in type and dimension as approved by the PMO/Engineer:

- ISO 3458 - 1976	Assembled joints between fittings and polyethylene pipe (PE) pressured pipe - Test of leakproofness under internal pressure
- ISO 3459 - 1976	Polyethylene (PE) pressure pipe - Joint assembled with mechanical fittings-Internal under-pressure test method and requirement
- ISO 3501 - 1976	Assembled joints between fittings and polyethylene (PE) pressure pipe - Test of resistance to pull out
- ISO 3503 - 1976	Assembled joints between fittings and polyethylene pressure pipes - Test of leakproofness under internal pressure when subjected to bending

(3) Storing

The pipe shall be stored with plugs for both sides to prevent from intrusion of water and dust in a coiled status to drum out of direct sunlight. Extreme care shall be made to prevent any scarring or nicking of the pipe and from bearing on sharp

objects. Any pipe which has any cut or bruise than 10 per cent of the wall thickness will be rejected. Covering the pipe with a tarpaulin shall not be allowed.

10503 Valves

10503.1 Sluice Valves

Sluice valves shall be suitable for water supply works purposes in tropical conditions and shall be manufactured to comply with the requirements of :

- BS 5163 – 1986	Specification for Predominantly key-operated Cast Iron Gate Valves for Waterworks Purposes
- JIS B 2062 - 1974	Sluice Valves for Waterworks
- JIS B 2011 - 1988	Bronze Gate, Globe, Angle and Check Valves

Sluice valves shall be suitable for an actual working pressure as required.

All sluice valves shall be of double flanged, with flanges faced and drilled to conform to the dimensions specified in Clause "Jointing Pipes."

Spindles shall be cast iron, forged or rolled bronze, or stainless steel, and of the non-rising type and screwed so as to close the valves when rotated in the clockwise direction. The direction of closing shall be clearly cast on the valve cap.

All sluice valves to have stamped or inscribed lettering giving the following information:

i) Manufacturer's trade mark or name.

ii) Working pressure in PN (norminal pressure) indication for which the valve is suitable.

iii) The nominal size of the valve in metric units.

10503.2 Butterfly Valves

Dimension of face-to-face of Butterfly Valves shall comply with the requirements of ISO 5752 - 1982 Metal Valve for use in Flanged Pipe Systems Face-to-Face and Centre-to Face Dimensions and shall be of short dimension and flanged body ends.

The minimum service rating shall correspond to the presures as required. Care shall be taken when installing wafer type butterfly valves to ensure that the door when open does not foul the connecting pipe bore or any other adjacent connected valve or fitting.

Each valve, installed in the receiving tank, the rapid mixing tank and the filter, shall be operated for on-off and control with a hand wheel mounted on a headstock. The valves, installed in the valve chamber on the filtered water pipeline from the existing filter and in the flowmeter and valve chamber on the filtered water pipeline from the rapid sand filter, be operated with a hand wheel through a gear box with a position indicator.

Where the valve is mounted in a horizontal pipe with the shaft horizontal, it should be fitted in the pipeline so that the lower portion of the disc moves in the same direction as the flow when opening the valve.

10503.3 Sluice Gate

Sluice gates shall be square, rising stem and conventional closure type. The sluice gates shall consist of frames, gate slides, wedging devices, stems and stem couplings, stem guides and manual operators. The sluice gates shall be of cast iron, fully bronze mounted with side wedges for seating head conditions. All gate components shall be designed in accordance with the manufacture's standard to safely withstand the heads to be encountered.

Slide shall be made of cast iron, one piece with strengthening ribs where required, and reinforced section to receive the seating faces. Seating faces shall be made of bronze or stainless steel. They shall be secured firmly in frame and slide faces.

The sluice gate shall be equipped with adjustable side-wedging devices to provide contact between the slide and frame facing when the gate is in closed position. Wedge shall be fully adjustable and so designed that they will remain in the fixed position after adjustment.

The operating stems shall be of a size to safely withstand, without buckling or permanent

distortion, the stress induced by normal operating forces. The stems shall be made from solid bar stock of stainless steel. The stems shall be designed to transmit compression at least two (2) times of the rated output of the operator. Where stems are furnished in more than one piece, the different sections shall be jointed together by solid couplings.

10503.4 Air-Release Valves

Air-release valve to be provided in the raw water transmission pipeline by flanged joint shall be installed as shown on the Drawings and directed by the PMO/Engineer. The air-release valve shall be manufactured to comply with the requirement of JIS B 2063 - 1987 Air Vent Valves for Water Works, Quick Type Class 2 (0.74 MPa) Flanged End or other standard approved equivalent. A ball valve shall be provided on the air-valve for shutting to inspect the air-release valve.

10503.5 *Headstocks*

For the purpose of operating flow control valves, drain valves, filter operation valves and sluice gates, headstocks operated by hand are equipped on the valves and gates. Headstocks shall consist of stand, spindle gear cover, handle, opening indicator, and include other necessary accessaries. Main body and handle shall be of cast iron and spindle be of mild steel round bar with a tensile strength N = 400 kg/mm². All headstocks component shall be designed to safely withstand the operation in accordance with the manufacturer's standard. The Contractor shall furnish the headstocks with an appropriate spindle length in accordance with the Drawings. The headstocks are classified to two types by a operating place and a diameter of valves and gates as follows :

Type		Using Place		
Type-A	Handwheel type	for less than 300 mm in diameter of valves		
Type-B	Bevel gear type	for	(1)	more than 350 mm in diameter of valves
			(2)	filter operation valves, 200 mm to 350 mm in diameter
Type-C	Bevel gear type for gates, rising stem			

10504 Pipelaying Works

10504.1 Pipe Trench

(1) Alignment, Gradient and Setting Out of Pipeline

The Contractor shall provide proper leading frames and boning rods of predetermined measurement for the boning in of individual pipes to correct alignment and depth to be laid. The leading frames shall be situated vertically above the line of pipes and there shall at no time be less than three leading frames in position on each length of pipeline under the construction to any one gradient. In setting out leading frames, the Contractor shall transfer levels from bench-marks which will be indicated by the PMO/Engineer.

The leading frames are to be provided fixed and maintained by the Contractor at his own expense. The Contractor will be held responsible for any errors which may occur in the execution of the work through the leading frames being disturbed faulty setting out or any other cause whatsoever and he shall make the works good at his own.

After leading frame have been erected and before excavations are commenced, the alignment and levels thereof will be checked by the PMO/Engineer's Representative.

(2) Trench Excavation

The trench excavation prescribed in Sub-section 10202.3 Trench Excavation shall be applied for pipelaying works of the raw water transmission, raw water and filtered water pipes in the yard of treatment works, backwash pipe, waste water drain pipe and other interconnecting pipes. The trench shall be excavated in accordance with the Drawings or directed by the PMO/Engineer.

The width of trenches shall be within the limits of width shown in the table below or such other width shown in the Drawings up to a minimum of 300 millimetres above the top of the pipe barrel. Battering the sides of trenches shall only be permitted above this level where approved.

Nominal Internal Diameter (mm)	Min. Trench Width (mm)	Max. Trench Width (mm)
100	430	630
150	490	690
200	550	750
250	610	810
300	680	880
350	910	1,110
400	970	1,170
450	1,030	1,230
500	1,100	1,300
600	1,240	1,440
800	1,460	1,660

After both the excavation of a section of pipe trench and the placing of the pipe bed have been completed by the Contractor, they shall be inspected and passed by the PMO/Engineer's Representative before pipelaying is commenced. Just before pipelaying, the trench shall be cleaned of all stones soil and other debris that might have fallen therein.

(3) Type of bedding and backfill materials

Type and materials for bedding and backfill shall be as follows :

Type	Materials
Granular bedding Type A	crashed stone, crushed brick
Selected fill Type B	uniform readily compactable materials free from tree roots, vegitable excluding clay lumps retained on 75 mm sieve and stones retained on 25 mm sieve
Granular bedding Type C	crashed stone, crushed brick to pass a 10 mm sieve

(4) Bedding for Pipes

Where rigid pipes are to be bedded on granular material, bedding shall be as shown on the Drawings. The granular material shall be placed by hand in the excavation

below the level of the pipe barrel and shall be tamped and rammed by hand in layers not exceeding 150 millimetres thick before compaction, to provide a dense, well compacted bed free from soft spots throughout the length of the pipeline.

The bottom of the trench or surface of the bed shall be finished to a smooth even surface at correct levels to permit the barrel of the pipe to be solidly and evenly bedded throughout its whole length between joint and sling holes.

The preparation of the trench bottom or surface of the bed shall be completed for at least one full pipe length in advance of the pipelaying, except where in exceptional circumstances another arrangement is approved.

No bedding material shall be placed in trenches containing water.

Where granular bedding is to be used, stones, bricks or similar materials shall not be used below or against the pipes to locate them in position in the trench or to level the pipes. Sufficient of the infill materials shall be placed around the barrels of pipes to prevent movement.

(5) Backfill of Trench

Backfill of the trench shall be placed with type B material in 150 mm layers and compacted by approved hand tampers. The remainder of the surround comprising approved type B material above the level of the crown of the pipe shall be placed in 150 mm layers each layer being fully watered in and compacted by hand tampers. Successive layers not deeper than 150 mm shall be added and compacted fully watered in to the approval of the PMO/Engineer's Representative until the surround is compact and complete to the levels shown on the Drawings. In all cases the backfill material shall be placed by hand to a depth of 300 mm above the crown of the pipe and shall be free from clay lumps large stones rock or other substances which may cause damage to the permanent works.

10504.2 Temporary Side Support and Sheeting

Temporary side supports and sheeting shall be provided by the Contractor to support adequately the trench sides from collapse during the placing of bedding, haunching surrouding or anchoring materials and care shall be taken in placing pipes to prevent damage

to the pipe coating or to adjacent structures or equipment.

10504.3 Pipelaying and Jointing of Pipes

(1) Pipelaying in Trench

Each pipe and fitting shall be carefully examined both inside and outside for any damage including cracks in lining and crushed end laminations and any pipe or fitting found to be faulty shall be marked and set aside. Pipes with damaged ends shall be either completely replaced or have the ends cut off trimmed and turned at the discretion of the PMO/Engineer.

All dust dirt and foreign matter shall be removed from the inside of all pipes and case shall be taken to ensure that they remain clean during laying works.

(2) Pipelaying in Structures

All piping shall be rigidly supported from the structures by approved hangers, inserts, or supports with adequate provisions for expansion and contraction. Piping shall not be supported from other piping or from stairs, ladders, or walkways unless specifically directed by the PMO/Engineer.

Where piping is installed on structural steel supports, blocking of pipe rolls shall be provided to arrest lateral pipe movement.

All vertical pipes shall be supported at each floor or at intervals not to exceed 3 metres, by approved pipe collars, clamps, brackets, or wall rests, and at all points necessary to ensure rigid construction.

Each section of pipe line shall be laid out and all connections (cemented, welded, screwed) made while the pipe is supported on temporary supports. After completion of connections, the pipe shall be clamped in position. When piping is correctly installed on its permanent supports, a clamped pipe connection or pipe may be loosened or removed without displacement of the pipeline.

(3) Jointing

Following specification shall apply to the various types of joints in pipelines :

Push-in Joint of Ductile Iron Pipe

In the Push-in Joint a suitably shaped rubber joint ring is inserted into a locating groove machined within the interia face of the socket. Then, spigot end of the pipe to be jointed is positioned centrally within the socket and pulled the spigot into the socket by a jointing equipment such as a lever-block. The rubber ring shall be of styrene butadiene rubber (SBR) and the shape shall be in accordance with the manufacturer's standards.

All spigot to be used with a push-in type shall be chamfered by a grinder. The Contractor must include in his respective rates for chamfering the ends of any cut pipes to be used with these joints.

The maximum deflection of this joint type is allowed at 4 degrees after jointing.

Flanged Joint

The flanges shall comply with the requirements of ISO 7005 Metalic Flange Part 1 Steel Flange and Part 2 Cast Iron Flange. Flanges shall be correctly and the component parts, including any gasket cleaned and dried. Gasket shall be fitted smoothly to the flange without folds or wrinkles.

The faces and bolt holes shall be brought fairly together and the joints shall be made by gradually and evenly tightening bolts in diametrically opposed positions. Only standard length spanners shall be used to tighten the bolts. The protective coating, if any, of the flange shall be made good when the joint is completed.

Gasket shall be cut to the proper size so that no part will protrude. Prior to application of gaskets, the face of flanges shall be thoroughly cleaned. All gasket supplied with each flange fitting shall be styrene butadiene rubber (SBR) conforming to B.S. 5292 - 1980 Specification for Jointing Materials and Compound for installation using Water, Low-Pressure Steam or 1st, 2nd and 3rd Family Gases, or JIS K 6353 "Rubber Goods for Water Works" Class III, or other standard approved

equal. Thickness of gasket shall be 3 millimetres.

Bolts, nuts and washers for flanged joints shall be cadmium or zinc plated and shall comply with the appropriate table of B.S. 4504, Specification for Flanges and Bolting for Pipes, Valves and Fittings. Metric series or other standard approved equal.

Bolts in flanged joints shall be tightened alternately on opposite ends of joints diameters, in rotation around the flange and evenly.

Slip-On-Type Coupling Joints (Viking Johnson Coupling) for Steel Pipe

The slip-on-coupling joint is to be used with plain end steel pipes. The slip-on-type coupling joints shall be suitable for steel pipes as specified under Sub-section 10502.2 "Steel Pipe" and shall comply with the requirements of internationally accepted standards approved by the PMO/Engineer. The Contractor shall submit detailed information of the joint to the PMO/Engineer for his approval.

The coupling sleeve shall have a centre register which acts as locating stop. The joint shall be capable of accommodating small expansion and contraction movements but shall not mechanically prevent separation of the pipes.

The joint and pipes shall be thoroughly cleaned to remove oil, grit, excess coating and other foreign matters before assembling the joints. Bolts shall be tightened alternately on opposite ends of diameters and in rotation around the pipe. When properly assembled, the joint rings shall be evenly pressed at all points.

Screwed Joints

All pipe thread shall conform to the recommendations of "Pipe Threads for Gas List Tubes and Screwed Fittings Where Pressure-Tight Joints are Made on the Threads (ISO/R7)," Table 2.

All threads for screw joints shall be clean, machine cut, and all pipe shall be reamed before erection. Each length of pipe as erected shall be up-ended and rapped to dislodge dirt and scale.

Screwed joints shall be made up with good quality thread compound and applied to the male thread only. After having been set up, a joint must not be backed off unless the joint is completely broken, the threads cleaned, and new compound applied.

Joints on uPVC Pipes

Pipes 40 millimetres in diameter or smaller can be of a solvent welded joints. The pipe shall be supplied with interchangeable sockets performed at the factory and of such internal diameter that it takes the plain end of the pipe with the same nominal diameter.

The joint shall sustain the end thrust to which the pipe shall be subjected. The Contractor shall supply sufficient quantity of the cleaner and adhesive which shall be required to make the joints with the pipes.

Only the solvent cement recommended by the manufacturer for his pipe joint system shall be used and his instructions on the making of the joints shall be closely followed. Excess solvent cement shall not be applied to the inside of the pipe socket and all surplus solvent shall be removed from the joint and the pipe. Any solvent falling on the trench formation shall be removed by excavating the contaminated soil. Solvent welded pipes jointed outside the trench shall not be lowered into place until the elapse of time recommended by the manufacturer. The time allowed for curing shall be increased with lower temperatures.

Pipes of 50 millimetres or larger in diameter shall consist of a grooved socket at one end of the pipe. The socket shall be designed to give a clearance fit of the outside diameter of the parent pipe. The sealing medium which shall seat in the grooved shall be rubber ring.

If the formation of the socket and groove results in the thinning of the pipe, it shall be compensated for by shrinking on the outside of the socket area a reinforcing sleeve of the same material as the pipe. The socket and groove shall incorporate no sharp angles where the stress points are created.

The joints shall take 10 per cent deformation of the spigot at the point where it enters the socket without leakage from the pipe when subjected to the test pressure specified for the pipe. Thermal expansion of the pipe shall be accommodated in the

joint. The joint shall be capable of linear deflection up to 3 degrees.

The sealing ring shall be of first grade natural rubber and the physical properties of the mix shall meet the requirements of B.S. 2494 – 1976 Specification Materials for Elastomeric Joint Rings for Pipework and Pipeline, JIS K 6353, or other standards approved equal.

Joints on PE Pipes

The joints of polyethylene pipes shall be made by welded joint or sleeve joint. For the buttjoint be electrowelding, both outside ends of the pipe shall be bevelled by a tool or a file or a knife, heated by the welder and welded by pushing the welding rod for polyethylene with 3 mm in diameter after cleaning the butt portion.

For the polyethylene sleeve joint, the pipe and sleeve joint shall be simultaneously inserted in a mold heated up to appropriate temperature about 200°C. After confirmed fusing status of the pipe, the pipe sleeve shall be pulled out from the mold and connected with the solvent cement.

10504.4 Protection of Pipes and Joints

(1) *Flanged Joints Protection*

After jointing in the case of cast-iron or steel joints, the flanges, bolts, nuts and barrels of the pipes for a distance of 75 mm from the root of the flange are to be painted two good coats of black non-toxic bituminous paint of approved manufacture.

(2) Slip-on Couplings Protection

When the joint has been assembled it shall be encased with approved bitumen hot poured into the annulus formed between the pipe joint and mould box.

10504.5 Installation of Valves

Valves shall be set and jointed to pipe in the manner specified in applicable portions of Sub-section 10504.3 Pipelaying and Jointing of Pipes.

Care shall be taken to prevent damage to all valves, and their ancillary equipment. Valves and ancillary apparatus shall be stored in clean conditions and in a manner that excludes all water. Where directed, headstocks, gearing or indicators shall be removed, adequately labelled for identification, stored carefully in weatherproof premises and be reconnected after erection of the valves.

The gunmetal faces and seats of all valves shall be kept clean. No valve shall be closed without first wiping the faces with a clean cloth. The cavity beneath the valve door shall be thoroughly cleaned by hand. If fouling matter is deposited accidentally, it shall be either dissolved or carefully removed by methods that do not involve scraping of the gunmetal faces.

Unless otherwise directed, all valves, fittings and special shall be individually supported and their weight shall not be borne by the pipelines, joints or couplings. All supports for valves shall be of concrete Class D.

All valves shall be set so that operating spindles are truly vertical unless otherwise shown on the Drawings or directed.

Where air–release valves are to be placed, the Contractor shall ensure that the highest point in the pipeline is determined by the levelling. Air–release valves shall be checked before the pipeline is charged to ensure that the balls and faces are not deformed or split and that there is no dirt or other deleterious materials in the cavities of the body. All air nozzles shall be probed to see that they are clear. No air–release valve shall be stored before erection on the open in sunlight, or upside down to expose the balls and air cavities.

Before each valve is put into service all gear bearings and spindles shall be oiled with an approved oil as recommended by the valve manufacturer. Oil baths shall be topped up to the appropriate levels and all grease nipples charged with grease of approved manufacturer. No deleterious matter shall be allowed to come into contact with the working faces and oil sumps shall be maintained clean.

The rates in the Bill of Quantities shall cover for the supply, storing, handling, installation and jointing, together with all bolts, washers, gaskets and lubricants, etc.

10505 Valve Chamber, Flowmeter & Valve Chamber and Valve Boxes

10505.1 Valve Chamber and Flowmeter & Valve Chamber

The Valve Chamber and Flowmeter & Valve Chamber shall be constructed for the filtered water pipelines from the existing slow sand fiter and rapid sand filter, respectively, with reinforced concrete as shown on the Drawing. The valves will be operated by readily accessible handle in the chamber.

Covers and frames for manholes shall be carefully set in position shown and the frames shall be solidly bedded in cement mortar (mixed ratio of 1 : 2).

10505.2 Valve Box

Unless otherwise specified or directed, valve box for washoutpipe shall consist of concrete pipe of DN 225 (inside diameter of 225 mm) with the length adjusted to the required height and surface box at the top. The concrete pipe shall be fixed in the position truly vertical on precast concrete base slab which shall be bedded on well compacted granula materials of Type A.

Surface box shall be of cast iron hinged at one end produced to fit the top of the concrete pipe section. The surface box shall be surrounded by concrete to prevent from moving by traffic loadings, etc.

The surface valve box shall not transmit shock or stress to the valve and the lid of the box shall be flush with the surface of the finished pavement or such other level as directed by the PMO/Engineer.

10505.3 Air-Release Valve Box

Upon installation of Air-release Valve, the air-valve box shall be constructed as soon as possible to prevent the valve from nuisance during the construction works. The air-valve box consists of precast concrete pipe as a chamber and a manhole cover made of checkered plate with stiffener as shown on the Drawing. The manhole shall be equipped with chain and locks to be locked on a steel belt.

The metal portion shall be painted with 3-ply of tar epoxy compound on the primer painting

or other paint as approved by the PMO/Engineer.

10506 Thrust Block

At bend junction and stop end on pressure pipelines the Contractor shall construct a thrust block of concrete Class B to the dimensions shown on the Drawings or ordered by the PMO/Engineer. Thrust blocks shall also be constructed on steep gradients and elsewhere as directed by the PMO/Engineer.

The additional excavation required to obtain a firm bottom formation and thrust face against undisturbed ground shall be made after the pipeline has been jointed. The Contractor shall ensure that the ground is solid and has not been softened by water from leakage or any other cause.

In the event of the thrust face of ground becoming softened or disturbed during excavation or concreting the Contractor shall remove the ground thus affected and replace it with concrete Class B at his own expense to the satisfaction of the PMO/Engineer.

10507 Temporary Piping Work for Raw Water Intake

The Contractor shall install temporary pipes for the raw water intake during a period of the construction works of intake to enable the raw water abstraction for the existing system without any disturbance of the present operation. Three pipes shall be provided with two lines of DN 450 mm and one DN 600 mm and connected to the existing raw water pipes as shown on the Drawing. Upon completion of the construction works, the temporary pipes shall be immediately removed.

The cost shall be included in the price in the Bills of Quantities.

10508 Temporary Coffer-Dam at the Site of Intake and River-Crossing

The Contractor shall construct temporary coffer-dams for water-shuttering on the river beds during a period of the construction works of intake and river-crossings. The coffer-dam construction consists of sheet pile installation and piling up sand bags for the intake and

sand bag piling for the river crossing.

The sheet piles shall be installed in a ditch with a depth of about 1.0 m to be dug on the river bed and a height sufficient to sustain HWL of overflow water for the dyke in the dry season. The pile shall be supported by waling and strutting. After completion of the construction works, the coffer-dams shall be immediately removed.

The cost shall be included in the price of the Bills of Quantities.

10509 Protection Fence for Falling Stone

The Contractor shall install the protection wall for falling stones from rocky face of the gorge along the raw water transmission pipeline as safety measures. The location of the protection wall shall be in IP No.6 to No.21 of survey points for the pipeline route as shown on the Drawings as directed by the PMO/Engineer.

The protection wall shall be installed with supporting posts and frames of structural steel having sufficient member section for holding the stones fallen and wire mesh before starting the pipelaying works. The supporting posts shall be built founded in situ Class B concrete and at least 1.0 meter interval. Lateral bracing and strutting shall be placed on the posts with appropriate interval. All structural steel members shall be painted with a non-toxic tar epoxy resin on an undercoat or other proper painting approved by the PMO/Engineer. Upon completion of the raw water transmission pipelaying works, the wall is requested to be left at the site for safety purpose. The Contractor shall submit the proposal as working drawing to the PMO/Engineer.

The cost shall be included in the price of the Bills of Quantities.

10510 Slope Protection

The slope surface cut to widen the new pipeline route shall be treated by a shotcrete work or other proper protection work in IP 25 to IP 32 and in IP 33 to IP 44 of survey points for the pipeline route as shown on the drawings. The Contractor shall submit the work plan on the protection to the PMO/Engineer for approval.

10511 Rehabilitation of the Existing Pipelines

The Contractor shall inspect the leakage condition for the existing raw water pipelines of 27 inches reinforced concrete pipe, 18 and 19 inches grey cast iron pipes and repair them by using appropriate band or other proper manner approved by the PMO/Engineer during the pipelaying work. Visible leakage spots of 30 shall be repaired.

The cost shall be included in the price of the Bills of Quantities.

10512 Connection to the Existing Pipeline

Before starting excavation works for sedimentation tanks and filters, the existing filtered water and wastewater drain pipelines in the treatment works shall be relocated in accordance with the Drawing. Besides, new filtered water pipes shall also be connected to the existing pipelines as shown on the Drawings.

For the connection works, the Contractor shall pay his attention to minimum duration for suspending the operation of treatment works under the direction of the manager of the treatment works and shall submit the work programme to the PMO/Engineer for approval.

10513 Marking of Pipe

Visible pipes, headstocks, valves and other fittings in the Treatment Works shall be painted or marked in accordance with the following colour scheme:

i)	Raw water	– Black
ii)	Settled water	– Light Brown
iii)	Clear water	– Light Blue
iv)	Drain	– Grey
v)	Air–scouring	– White

vi) Chlorine dosing – Red

vii) Alum dosing – Green

viii) Lime dosing – Yellow

On the body of headstocks installed on the filter operation floor, the following marks shall be written in black paint:

i) Inlet gate – IG

ii) Backwash inlet valve – BIV

iii) Backwash outlet gate – BOG

iv) Air–scoure valve – ASV

v) Filtered water valve – FWV

10514 Drainage Pipe Works

10514.1 General

This Section prescibes for drain ditches and waste water drain pipes to be furnished, placed and installed in or outside the treatment works.

10514.2 Concrete Ditch

(1) Precast Concrete Channel

Unless otherwise described or directed, precast channels shall be hydraulically pressed and they shall comply with the requirements of B.S. 340 – 1979 Specification for Precast Concrete Kerbs, Channels, Edgings and Quadrants or other standards approved.

Channels shall be constructed and laid with true grade and in the lines as shown on

the Drawings. Channels shall be laid by the aid of suitable boning rods and sight rails as described in 10512.3 "Concrete Pipe" and directed.

(2) Concrete Wall Channel

Cast-in-situ concrete wall channel shall be constructed as shown on the Drawings and in accordance with the Specifications described in **Section 2 "Earthworks"** and **Section 3 "Concrete Works."**

The concrete shall be Class A and the formed surface shall be F3 finish. The channel shall be constructed with true grade and in the line as shown on the Drawings.

The channel shall also be constructed by using leading board and suitable boning rods as described in 10512.3 "Concrete Pipe" or as directed by the PMO/Engineer. The surface of the bed shall be finished to a smooth even surface at the correct levels to permit the concrete to be evenly placed throughout its whole length.

10514.3 Concrete Pipe

(1) Materials

Al materials shall be of high grade and quality approved by the PMO/Engineer in selecting concrete pipes and jointing materials as specified below.

The concrete pipes shall be of spigot and socket for rigid joint type conforming to the requirements of for Drainage and Sewerage, B.S. 5911 : Part 3 – 1982 Precast Concrete Pipes and Fittings, or approved equal.

All pipes shall be straight, true in form and of full diameter throughout. The joint shall be that the internal and external diameters at one end are enlarged to form a socket into which the spigot end of a similar pipe can enter to form which sealed by use of cement mortar or other suitable material.

(2) Laying Pipes

Pipes shall be laid true and to the line and grade as shown on the Drawings and by the aid of leading boards and boning rods which shall be fixed, in accordance to the

requirement of the PMO/Engineer, at intervals not exceeding 15 metres and also by accurate levelling along the invert lines of the pipes by levelling instruments.

The Contractor shall set out the position and levels of the pipes and other works according to the Drawings and instructions of the PMO/Engineer, during the progress of the work.

The sight rails and boning rods shall be suitably and accurately planed and not warped. No defective or damaged sight rails or boning rods shall be allowed.

(3) Inspection

Each piece of concrete pipes shall be subjected to the test at manufacturer's factory. In addition, each piece of pipe shall be tested for soundness after delivery alongside the trench, by standing the pipe on one end (with a minimum of ground contact) and tapping the other end with a light hammer. Each end of pipes shall be thus tested.

All accepted pipes and fittings shall be marked so that the acceptance marks are plainly visible after installation in the trench and marks are not effaced by weather or handling.

Rejected pipes and fittings shall be removed from the site of the work immediately and permanently.

During the course of pipe laying, the PMO/Engineer will check both the grade and the line of direction at regular intervals. No backfilling shall be allowed unless grade and line, bedding and pipe interior have been checked and approved by the PMO/Engineer.

10514.4 Unplasticised Polyvinyl Chloride Pipe (uPVC Pipe)

(1) Requirement

Unplasticized Polyvinyl Chloride (uPVC) Pipes for drainage shall comply with the requirement of :

- MS 6 – 1981 Standard for Unplasticized PVC Sewer and Drain Pipe

(2) Joint Type

Joints shall be push-in type to scocket with rubber gasket in accordance with the above mentioned standard. Adaptor to be used for connecting to ductile iron pipe or steel pipe may be furnished with the requirement of the manufacturer's standard in type and outside and inside coating as approved by the PMO/Engineer.

(3) Storing

The pipe shall be stored out of any direct sunlight. Extreme care must be made to prevent any scarring or nicking of the pipe and from bearing on sharp objects. Any pipe which has any cut or bruise than 10 per cent of the wall thickness will be rejected. Covering the pipe with a tarpaulin shall not be allowed. Stacking of pipe shall not exceed 60 centimetres in height.

10514.5 Manholes

(1) General

Manholes shall be constructed complete with covers, steps, fittings and appurtenances in accordance with the details shown on the Drawings. At the opinion of the PMO/Engineer, manholes shall be constructed of precast concrete sections, concrete blocks, or cast-in-situ concrete.

(2) Materials

Precast concrete manholes shall be reinforced and shall comply with the requirements of B.S. 5911 : Part 1 -1981 Specification for Pipes and Fittings with Flexible Joints and Manholes. Precast concrete manholes units may be complete with invert and benching or may be supplied without invert and benching, as directed by the PMO/Engineer. The dimensions of precast concrete manholes shall be in accordance with those shown on the Drawings.

Manhole step irons shall comply with the requirements of B.S.1247 - 1975 Specification for Manhole Step Iron. For precast concrete manholes, step irons shall be galvanised malleable cast iron.

Manhole covers and frames shall be of cast iron and shall comply with the materials, workmanship coating etc. of requirements of applicable portions of B.S. 497: Part 1 – 1976 Cast Iron and Cast Steel or other standard approved equivalent. The covers shall have clear openings as shown on the Drawings.

(3) Construction

Manholes shall be constructed as shown on the Drawings. In no case shall the invert section through a manhole be greater than that of outgoing pipe. The shape of the invert shall conform exactly to the lower half of the pipe in connects. Side branch shall be connected with as large radius curve as practicable. All invert shall be trowelled to a smooth clean surface.

All manhole covers and frames shall be fixed in the position shown, the frames shall be solidly bedded in cement mortar so that the covers when in position are fair and even with adjacent surfaces. Where shown or directed, frames shall be bedded on from one to three courses of brickwork or concrete blocks in cement mortar.

(4) Workmanship

Water shall be removed from excavation, and a minimum of 200 millimetres of crusher run base shall be provided where the soil condition requires and be thoroughly compacted with a mechanical vibrating or power tamper.

Concrete base shall be constructed as shown on the Drawings. The concrete shall be vibrated thoroughly to density and screed it so that the first precast manhole section, or concrete is to be placed with a level and uniform bearing for the full circumference.

Sufficient mortar shall be deposited on base to assure watertight seal between base and manhole walls. Concrete shall be so placed that there is no segregation of the aggregate. Concrete shall be cured for seven days in a manner approved by the PMO/Engineer. After removal of the forms, all rock pockets, form tie holes and irregularities shall be patched with a stiff mixture of Portland cement and sand mixed in the same proportion as the original walls to produce a uniform and flat surface.

Precast manhole sections to be jointed shall be carefully inspected. Sections with

chips and cracks shall not be used. Clean ends of sections of foreign materials and place preformed plastic gasket material on groove of lower section in conformance with manufacturer's recommendations. Set next section in place, and wipe or otherwise clean the excess preformed plastic gasket material from the inside of the joint.

When keylock joint is used, it is the intent that the void between the tongue-and-groove be completely filled with preformed plastic gasket material and that interior and exterior end faces of the section to be placed seat fully on the previously placed section. Completed manholes shall be rigid and watertight.

Manhole invert shall be constructed in conformance with the Drawings, and with smooth transitions to insure an unobstructed flow through manhole. All sharp edges or rough sections which tend to obstruct flow shall be removed. Where a full section of pipe is laid through a manhole, break out the top section as indicated and cover exposed edge of pipe completely with mortar. Trowel all mortar surface smooth.

10514.6 Testing of Pipes

Wherever possible, testing shall be carried out from manhole to manhole. Short branch drains connected to a main sewer between manholes shall be tested as one system with the main sewers. Long branches shall be tested separately. Sewers shall be tested : (i) after laying, including the placing of concrete if any, but before backfilling, and (ii) after backfilling has been completed.

Sewers shall be tested for infiltration after backfilling. All inlets to the system shall be effectively closed and the residual flow shall be deemed to be infiltration. The amount of infiltration shall not exceed 0.1 litre per hour per 100 linear metres per millimetre of nominal bore of the sewer. Infiltration to manholes shall not exceed 5 litres per hour per manhole.

10515 Measurement and Payment

Measurement for payment for the works specified in this Section "Pipe Work" will be made based on the works unit as shown on the Bill of Quantities or directed by the PMO/Engineer as follows :

Work Items		Measurement	
1)	Pipe Materials	–	linear metre along pipe centre line including lengths occupied by fittings and valves in trench work
		–	linear metre along pipe centre line excluding lengths occupied by fittings and valves in the gallery or outside trench
2)	Valves and headstocks	–	number installed including fitting to be connected in the valve chamber
3)	Pipe Trench	–	linear metre along trench centre line
4)	Valve and Flow metre chamber and Valve Box	–	number actually constructed as shown on the Drawings
5)	Thrust Block	–	number actually constructed as shown on the Drawing
6)	Drainage pipe	–	linear metre along pipe centre line
7)	Manhole	–	number actually constructed as shown on the drawing

Payment for the work items mentioned above will be made at the unit price per unit stated in the Bill of Quantities, which shall include the costs of all labour, materials and equipment required in the construction. These unit prices shall also include the costs of:

1)	Pipe Materials:	furnishing, transporting from the bonded warehouse to the Site, lowering, setting, jointing, pressure testing and other items necessary to complete the work.
2)	Valves and Head Stocks:	furnishing, transporting, lowering, setting, jointing and other items necessary to complete the work.

3)	Pipe Trench:	excavation, trimming of invert, bedding, selecting of backfilling materials, backfilling with tamping, excess soil disposing, and other items necessary to complete the work.
4)	Valve and Flow Metre Chamber and Valve Box:	excavation, bedding. concrete works, formwork, reinforcing bar work, iron steps, manhole cover for the chamber and concrete pipe, iron box for the valve box, backfilling with tamping, excess soil disposing and other items necessary to complete the work.
5)	Thrust Block:	excavation, bedding, concrete works, formwork, reinforcing bar work, backfilling with tamping, excess soil disposing and other items necessary to complete the work.
6)	Drainage Pipe:	furnishing, transporting, lowering, setting, jointing, testing and other items necessary to complete the work.
7)	Manhole:	furnishing, transporting, excavation, bedding, concrete works, formwork, reinforcing bar work, iron steps, manhole cover, cement mortar, setting, backfilling with tamping and other items necessary to complete the work.

10600 TESTING AND DISINFECTION

10601 General

All the water supply facilities shall be tested and disinfected, except raw water system for which disinfecting is not required, after cleaning and scouring. The Contractor shall furnish all equipment, labour and materials required for testing and disinfecting water retaining structures and pipelines as specified. Water will be supplied from the existing filtration plants for cleaning, scouring and disinfecting the relocated and new filtered water pipelines, but chemicals of hypochlorite or chlorinated lime shall be provided by the contractor for disinfecting water retaining structures and pipelines. All testing and disinfecting operation shall be done in the presence of the PMO/Engineer, or his representative.

The water retaining structures include, but not limited to, receiving tank, rapid mixing tank, flocculation and sedimentation tanks, rapid sand filters and wastewater and sludge ponds.

The cost incurred for the testing and disinfecting pipelines and structure shall be included in the rate in the Bills of Quantities.

10602 Testing and Disinfecting of Pipelines

10602.1 Pressure Testing for Pressure Pipeline

The test pressure is to be at least 1.5 times the normal working pressure for the class of pipe being tested, unless otherwise directed, and shall be applied by means of a test pump connected to the pipe in a manner satisfactory to the PMO/Engineer. All the necessary apparatus for the testing shall be furnished by the Contractor. The Contractor shall conduct the testing under the supervision and direction of the PMO/Engineer.

The Contractor shall provide for transmitting the unsupported end thrusts to solid ground at the ends or into the sides of the trenches. Before testing, he shall ensure that the anchorage of bends is complete and that all branch outlets taking end thrust are properly stayed.

Testing shall not be permitted against a closed valve. In-line valves shall be left open.

Terminal valves, hydrants, scour valves and the isolating valves of air valves shall be open, and shall be fitted with blank flanges except that where air valves are already fitted they shall be in service during the test. Scour pipes shall be connected only after pipeline testing is complete.

When testing, the pipeline shall be charged with water and all air released. Care shall be taken during the charging of the mains to provide free outlets for air to prevent surging and water-hammer. The pipeline shall then be brought up to and maintained at operating pressure and left for a period of not less than 24 hours to allow for absorption and achieve stable conditions. Thereafter water shall be added by pumping until the test pressure is reached, when the pump shall be isolated. If a drop in pressure occurs, the pump shall be reconnected and the quantity of water added to restore the test pressure shall be measured. This procedure shall be repeated at regular intervals for a period of 2 hours.

The amount of water added or lost shall not exceed 0.1 litre per millimetre nominal internal diameter per kilometre length of main per 30 metres head for each twenty-four hours.

Interim tests shall be applied to sections of all continuous pipelines in lengths not exceeding 1000 metres. The first sectional interim test on each continuous length of pipeline shall be carried out after the bedding of the pipeline and after such partial backfilling as is necessary to provide 300 millimetres depth of material over the crown of the pipe, subject to the tops of all joints being left exposed.

Subsequent interim tests may, at the discretion of the PMO/Engineer, be carried out with the trench backfilled (except for the replacement of soil or turf).

The Contractor shall ensure that no erosion or silting occurs in water courses from the discharge of test water.

10602.2 Disinfecting of Filtered Water Pipeline

Pipeline shall be disinfecting after testing, and scouring.

Chlorine solution shall be applied as the pipeline is being filled and dosing shall be continued until the pipeline is full and at least 50 milligrammes per litre of free chlorine have been made available. Chlorine gas shall not be injected direct to the pipeline from a cylinder otherwise than through an approved chlorinator and care shall be taken to ensure

that there is no flow back into the preceding sections of the pipeline.

Chlorine residual tests shall be taken at the end of the pipeline. The process shall be repeated until the chlorine residual is not less than 10 milligrammes per litre.

The Contractor shall dispose of the waste chlorine solution in such a manner as to avoid the pollution of natural waters and of reservoirs and artificial watercourses. The Contractor shall comply with any directions which the PMO/Engineer makes in respect of such disposal.

10603 Cleaning, Scouring, Testing, and Disinfecting of Water Retaining Structures

10603.1 Scouring of Structures

On the completion of the construction and before disinfecting, all internal surfaces shall be scoured and the structures flushed in such a manner as to remove all dirt and grit which may have accumulated during construction.

10603.2 Testing of Structures

Water retaining structures on completion shall be tested in accordance with the provisions of Clause 32 of B.S. 5337 – 1976 Code of Practice for the Structural Use of Concrete, for Retaining Aqueous Liquids. Structures shall be deemed to be watertight if, after making due allowance for evaporation and absorption, the total drop in surface level does not exceed 10 millimetres in 7 days. Visible leaks and workmanship which is defective shall be rectified notwithstanding the fact that the structure may have passed the hydraulic test.

10603.3 Disinfecting of Structures

A solution containing 50 milligrammes per litre of chlorine shall be prepared and thereafter brushed vigorously into the internal surfaces of the structure. The Contractor shall provide goggles and protective clothing for the men doing this work.

A contact period of not less than 30 minutes shall be allowed before flushing the surface with clean water.

The Contractor shall dispose of the waste chlorine solution in such a manner as to avoid the

pollution of natural waters and of reservoirs and watercourses. The Contractor shall comply with any directions which the PMO/Engineer makes in respect of such disposal.

10700 METAL WORKS

10701 General

10701.1 Scope of Work

These Specifications shall cover the fabrication, erection and other general requirements incidental to structural steelwork and miscellaneous metalwork to be made in accordance with the Drawings.

The Specifications of this Section are applicable for all metal works unless otherwise specified in Chapter II "Builder Works."

10701.2 General Requirements

The metal works, when completed, shall be suitable in every respects for the service intended, and the Contractor shall, at no extra cost, supply all the materials and do all the works which may be reasonably implied as being incidentals to the work.

The Contractor shall be responsible for all metal works, testing and placing in satisfactory operation to complete metal works to the approval of the PMO/Engineer.

The Contractor shall submit complete sets of detailed working and shop drawings and schedules of all metal works.

10701.3 Materials

Materials used in the work shall meet the requirements of the following standards:

i) Structural steel

-B.S. 4360 - 1986	Specification for Weldable Structure Steels (Grade40A)
-JIS G 3101 - 1987	Rolled Steel for General Structure (SS400)

ii) Structural steel for welding

-JIS G 3106 - 1988	Rolled Steels for Welder Structure

iii) Steel pipe

-B.S. 1387 - 1985	Specification for Screwed and Socketed Steel Tubes and Tubulars and for Plain End Steel Tubes Suitable for Welding or for Screwing to B.S. 21 Pipe Threads (Medium)
-JIS G 3452 - 1988	Carbon Steel Pipe for Ordinary Piping (SGP)

iv) Galvanised steel pipe

-B.S. 1387 - 1985	(Medium, Galvanised)
-JIS G 3442 - 1988	Galvanised Steel Pipes for Water Service (SGPW)

v) Stainless steel

-B.S. 1449: Part 2-1983	Specification for Stainless and Heat-Resisting Steel Plate, Sheet and Strip
-JIS G 4303 - 1988	Stainless Steel Bars (SUS B)

JIS G 4304, JIS G 4305, JIS G 4306, JIS G 4307,JIS G 4308 and

-JIS G 4309 - 1988	Stainless Steel Wires (SUS W)

vi) Cast iron

-B.S. 1452 - 1977	Specification for Gray Iron Castings (Grade 14)
-JIS G 5501 - 1989	Gray Iron Castings (FC 25)

vii) Bronze casting

-B.S. 1400 - 1985	Specification for Cooper Alloy Ingots and Copper Alloy and High Conductivity Copper Castings
-JIS H 5111 - 1979	Bronze Castings

All steel be free from excessive rust, pitting and other defects. All materials shall be thoroughly straightened in the shop without injury before being laid off or worked in any way. Material that has been split or permanently injured shall not be used.

Materials for welding shall be in accordance with the recommendation of the manufacturer of the material to be welded and in accordance with the requirements of B.S. 5135 - 1984 Specification for Process of Arc Welding of Carbon and Carbon Manganese Steels or other standards approved equal.

10702 Bar Screen

The bar screen shall be separated into nine parts and fabricated with angles and round steel bars as shown on the Drawing. To enable sliding of the screen, a channel shall be built in the both sides of wall fixed by anchor bolts welded on the reinforcing bars of wall. In addition, supporting angle shall be built in the bottom base for sustaining the screen and supporting channels be equipped on the wall behind the screen as indicated on the Drawing.

The screen shall be painted with 3-ply of non-toxic tar-epoxy compound on the primer painting or other paint as approved by the PMO/Engineer.

10703 Handrails

Railings shall be double or single row type with vertical posts or wall anchorage with dimensions all as indicated on the Drawings and specified herein.

Where steel toe boards are indicated on the Drawings, they shall be 9 millimetres thick steel plate of 125 x 125 millimetres size attached to the railing posts by means of welding to prevent movement.

Fasteners for jointing rails will only be permitted at removable sections, expansion joints, or as shown on the Drawings.

10704 Ladder

Unless otherwise shown or directed, ladder shall be fabricated of 75 mm by 12 mm thick flat bar welded with 20 millimetres in diameter of round steel bar at 300 millimetres interval as shown on the Drawing. Ladder shall be painted with bitumen compound paint on the primer for anti-rust steel.

10705 Grating

Galvanised steel gully gratings and frames shall comply with the requirements of manufacture's standard.

Gratings shall be designed with sufficient strength and thickness so that their deflection under design load does not exceed 1/240 of their span. Gratings shall be designed for a live load of 500 kg/m^2. No single piece of grating shall weigh more than 35 kg unless specifically shown otherwise on the Drawings.

10706 Manhole Cover and Frame

Manhole covers and frames to be installed on the valve and meter chambers shall be of cast iron and shall comply with the requirements of applicable portions of B.S. 497 as prescribed in Sub-section 10514.5.

The covers and frames shall be clean-moulded, accurately made in a workmanlike manner and coated with composition applied by heating and dipping whilst hot into the heated composition.

10707 Frame Support of Chain Block for Stoplogs

Frame support shall be equipped on the wastewater and sludge ponds for lifting and lowering stoplogs as shown on the Drawings. The frame supports are of gate type of H-steel hung a chain block at the centre of beam as indicated on the Drawing.

Stoplogs shall be made of reinforced concrete with a dimension shown on the Drawings. The stoplog shall be attached with hooks on the both sides for use of wire slings to hang it. For the purpose of protecting concrete sufaces of wall and stoplogs from damage by sliding, steel channel shall be built in both side groove of walls.

10708 Roof Light (Prism Glass Block)

All prism glass blocks shall be of approved manufacture in accordance with appropriate standards approved, and shall free from flaws, bubbles, specks and other imperfections, and unless otherwise shown or directed to the size 120 x 120 x 40 millimetres All prism glass blocks to be delivered in proper containers with marker's name, guarantee, type of glass block and sizes or weight of the block, attached to the outside of the container.

Glass blocks shall be accurately and neatly placed on the metal supports and jointed as shown on the Drawings strictly in accordance with the manufacturer's instructions.

Frame for the glass block shall be of ductile cast iron designed to have sufficient strength to withstand the expected dead and live loads, surfaces of which smoothly machined so as to affectively support the glass blocks. The frame shall be secured to the concrete floor by anchor bolts, nuts and anchor pieces as shown on the Drawings.

Blocks shall be placed on the frame true to the straight lines and grades and jointed with water proof cement mortar and sealings to keep water tight. All joint surfaces shall be pointed in white cement, and cleaned and polished on completion to the satisfaction of the PMO/Engineer.

10709 Painting and Protective Coatings

10709.1 Metal Coatings

All paints shall be obtained from approved suppliers. Unless otherwise agreed, all paints forming part or any one painting system shall be obtained from the same source.

All metal works shall be given shop primer after fabrication and cleaning but before shipping. After erection and installation the entire surfaces of all member shall be field painted as shown on the Drawings or as directed.

10709.2 Workmanship

Bare iron and steelwork including sheeting and pipes shall be thoroughly prepared by removing all dirt, rust and loose millscale to the satisfaction of the PMO/Engineer.

All rivets, welds, angle joints and openings shall be properly cleaned. Dust and other loose material shall be removed after cleaning. Oil and grease shall be removed with white spirit. The priming coat shall be applied before any contamination or rusting occurs.

Priming shall be carried out as soon as practical and in any case on the same day. Steelwork primed before delivery and damaged in transit shall have all damaged areas cleaned and patch primed immediately upon delivery. Areas damaged during erection shall be similarly dealt with.

Blast cleaning shall be performed in accordance with the requirement of B.S. 4232 - 1967 Specification for Surface Finish of Blast-cleaned Steel for Painting to the quality of surface finish as directed.

10710 Measurement and Payment

Measurement for payment for the works specifies in this Section "Metal Work" will be made based on the work unit as shown on the Bill of Quantities or directed by the PMO/Engineer as follows:

Work Items			Measurement
1)	Bar Screen	–	number actually installed as shown on the Drawing
2)	Handrail	–	linear metre actually installed as shown on the Drawing
3)	Ladder	–	number actually equipped as shown on the Drawing
4)	Grating	–	number actually installed as shown on the Drawing
5)	Frame Support of Chain Block for Stoplogs	–	number actually equipped as shown on the Drawing
6)	Roof Light (Glass block)	–	number actually equipped as shown on the Drawings

Payment for the work items mentioned above will be made at the unit price per unit stated in the Bill of Quantities, which shall include the costs of all labour, materials and equipment required in the construction. These unit prices shall also include the costs of fabricating, painting, transporting, equipping and other items necessary to complete the works for covering work items 1) to 6) in the above table.

10800 SITEWORKS

10801 Scope of Work

This Section priscribes the Site Works in the Treatment Works yard. The Contractor shall furnish all labour, materials, equipment, incidentals and the performance of all works necessary for construction of the embankment, road, footpath, retaining walls, fencing, markers and indicator posts as indicated on the Drawings and specified herein.

10802 Embankment

Excavated material used to form embankments shall be deposited and compacted in layers not exceeding 0.5 metre in depth as prescribed in Sub–Section 10205.3 Earth Embankment.

In tipping and forming the embankments the Contractor shall make allowance in the height and width of these for consolidation and shrinkage. On completion of the Contract the dimensions of the embankments shall be to the profile shown on the Drawings the necessary allowance being made for the surface finish. No slurry mud peat organic soft or otherwise unsuitable material shall be placed in embankments.

10803 Road

10803.1 Preparation and Surface Treatment of Formation

Preparation and surface treatment of the formation shall be carried out only after the completion of any specified sub–grade drainage and any services or ducts within the formation, the trenches for which have been reinstated in accordance with the requirements sub–section 10205.3 "Earth Embankment" and , unless otherwise approved, immediately prior to laying the sub–base.

The formation of rock–fill shall be thoroughly blinded with approved fine material to seal the surface, and shall then be completed, after being regulated and trimmed.

10803.2 Horizontal Alignments, and Surface Levels of Pavement Courses

Horizontal alignments shall be determined from one edge of the roadway pavement surface as shown on the Drawings. This edge as constructed and all other parallel alignments shall be corrected within a tolerance of ± 12 millimetres therefrom.

10803.3 Base Course

Formation shall be covered with a sub-base of clinker or ballast thoroughly compacted by a suitable roller to give a dense even surface. The compacted thickness of the sub-base shall be 200 millimetres.

The base course shall be 150 mm down basalt boulders hand placed and with surface voids filled with smaller gauge stone rolled by successive passes of an 8 -10 Ton roller until a well interlocked mass is obtained and consolidated to a depth of 200 mm.

10803.4 Wearing Course

The wearing course shall be 50 mm down crusher run watered and well rolled to give a finished depth of 50 mm.

The surface shall be swept clean lightly damped and then primed with bitumen coating. The road shall be closed to all traffic until the primer has soaked into the surface.

The primed surface shall then be sprayed with hot bitumen emulsion and sealed with 13 mm clean basalt chippings and rolled with an 8 - 10 Ton roller.

The bitumen shall comply with the requirement of B.S. 3690: Part 1 - 1982 Specification Bitumen for Road Purpose.

10803.5 Precast Concrete Kerbs, Channels, Edgings and Quadrants

Precast concrete kerbs, channels and edgings shall be hydraulically pressed and they and precast concrete quadrants shall comply with the requirements of B.S. 340 - 1979 Specification for Precast Concrete Kerbs, Channels, Edging and Quadrants, or other applicable standard.

10803.6 Guard Rail

The Contractor shall install a guard rail on the top of L-type retaining wall. The guard rail consists of supporting pole and beam which are made of steel complied with the requirement of the standards on structural steel. The pole shall be built with 2 meters interval in the concrete. The dimension of the guard rail for carriageway may be in accordance with the manufacturer's standard upon approval of PMO/Engineer.

The guard rail shall be painted with galvanising, more than 275 g/m2 of zinc for both side, and white coloured oil paint.

10804 Footpaths

Formations of footpaths shall be well cleaned and free from mud and slurry and properly shaped and consolidated by rolling to an even and uniform surface parallel to the required finished surface before the foundation work is commenced.

Precast concrete flags shall be hydraulically pressed and shall comply with the requirements of B.S. 368 - 1971 Specification for Precast Concrete Flags. The flags shall be 60 millimetres thick and, except where cutting is necessary, of a uniform width of 600 millimetres a minimum length of 450 millimetres and a maximum length of 1,200 millimetres.

Footpaths shall be laid to a crossfall of 1 to 50.

Flags shall be bedded dry on a 25 millimetre layer of coarse sand. Towards the end of the Defects Liability Period the Contractor shall level up all uneven path foundations and reset all flags to the design level after which all joints shall be grouted with cement mortar (1 : 3).

In situ concrete paths shall only be laid on undisturbed ground where the paths are curved in plan. They shall consist of concrete Class B 80 millimetres thick and shall be provided with a 50 millimetre by 6 millimetre batten joint every 1.5 metre which batten shall be left in. In situ concrete paths shall be finished smooth with a wood trowel.

10805 Masonry Retaining Wall

Rubble shall be sound and hard throughout, free from all defects and shall be obtained from approved quarry. Samples shall be submitted for approval and, if required for load bearing, stones will be tested for crushing strength. Any consignment of stone blocks delivered to the site shall be equal in every to the approved sample.

Rubbles shall generally be not less than 200 millimetres long.

The Contractor shall perform the wet rubble masonry wall for slope protection as shown on the Drawings or directed by the PMO/Engineer.

Unless otherwise shown on the Drawings or directed by the PMO/Engineer, wet rubble masonry wall rise on the bottom run of Class D concrete filled in 250 millimetres deep trench at the foot of wall.

The rubble stone shall be hand-placed with uncoursed close joints to the lines and graded as shown on the Drawings or as directed by the PMO/Engineer. The rubble stone shall be placed with 1:3 cement mortar after having joints thoroughly moistened. The spaces between the stones shall be filled with backfill crashed stone and the surface joint shall be finished with 1:3 cement mortar.

After completion of wet rubble masonry wall, it shall be cured with water for more than 10 hours as approved by the PMO/Engineer.

Weep-holes with PVC pipes of 20 millimetres in inside diameter shall be made in each 4 square metres of slope surface of the wet rubble masonry wall. The upper surface of wet rubble masonry wall shall be finished smooth with Class E concrete by wooden trowels.

10806 Fencing

Fencing shall comprise chain link fencing hung on concrete posts with inward cranked tips and three lines of 12 gauge galvanised steel barbed wire. It shall comply with BS 1722 Part 1 - 1986 *Specification for Chain Link Fences* except where otherwise specified herein and be type PLC 180 (heavy pattern). Chain link and all other metal parts of the fence shall be galvanised. Chain link and the line stirrup and tying wires shall be finished with a black

plastics coating. The bottom edge of the fence is to be protected by an in situ Class B concrete kerb 100 mm x 100 mm set flush to ground level.

The post shall be set at 3.30 m centre to centre and spacing of straining posts shall not exceed 30 metres in straight lengths of fence. All fence post and strut holes shall be filled with Class B concrete to a level 150 millimetres below finished ground level.

10807 Marker and Indicator Posts

The Contractor shall erect :

i) marker posts on the pipelines, and

ii) indicator posts at air-release valves and other fittings at the point directed by the PMO/Engineer. All posts shall be bedded in Class D concrete.

Marker and indicator posts shall be of vibrated precast concrete conforming to the dimensions and patterns shown in the type drawings with Class F Concrete and F3 finish. Indicator posts shall be provided with suitable holes for the attachment of name plates which shall be supplied by the Employer. All holes shall be free from obstruction and shall be accurately positioned.

10808 Measurement and Payment

Measurement for payment for the works specified in this Section "Site work" will be made based on the work unit as shown on the Bill of Quantities or directed by the PMO/Engineer as follows :

Work Items		Measurement
1)Embankment	–	as prescribed in Sub-Section 10209
2)Road	–	area actually constructed as shown on the drawing
3)Footpaths	–	area actually constructed as shown on the drawing
4)Masonry Retaining Wall	–	area actually constructed as shown on the drawing
5)Fencing	–	length in linear meter actually installed for fencing
6)Marker and Indicator Posts	–	number actually furnished and placed on the site

Payment for the work items mentioned above will be made at the unit price per unit stated in the Bill of Quantities, which shall include the costs of all labour, materials and equipment required in the construction. These unit prices shall also include the costs of :

1)	Embankment	:	as prescribed in Sub-Section 209
2)	Road	:	all materials of sub-base, wearing, bitumen for pavement and kerbs, edgings and quadrants, and transporting, constructing, installing and other items necessary to complete the works.
3)	Footpaths	:	furnishing, transporting, bedding, placing, jointing and other items necessary to complete the work.
4)	Masonry Retaining Wall	:	furnishing, transporting, earthworks, bedding, placing, back-filling, finishing upper surface, weep-holing and other items necessary to complete work.

5)	Fencing	:	furnishing, transporting, earth works, bedding, placing, footing, installing, wiring and other items necessary to complete work.
6)	Marker and Indicator	:	furnishing, transporting, placing, and other items necessary to complete work.

TECHNICAL SPECIFICATIONS

CHAPTER 2

BUILDING WORKS

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20100 GENERAL

20101 Scope of Work

These Specifications cover supply of all labours, materials and plants and the performance of all works necessary for construction of the buildings including building service works, such as domestic water supply system, drainage system, sanitary and sewerage system, air conditioning and ventilation system and fire protection system, and lighting and receptacle systems.

20102 General

(1) Materials and works

The Contractor shall supply all materials required for completion of the works in accordance with these Specifications.

If the Drawings do not identify incidental materials and works which are obviously necessary for the proper completion of the works, all such materials and works shall be deemed to have been included in the unit price stated in the Bill of Quantities for the appropriate items of the buildings construction works.

Unless otherwise specified, all materials and equipment which will become a part of the permanent works shall be new and of good quality, and shall be subject to inspection, examination and/or test according to the proper industrial standards.

(2) Standards

Unless otherwise specifically provided, the quality of materials, equipment and workmanship shall comply with JIS, BS or other equivalent standards approved by the PMO/Engineer.

(3) Working drawings and samples

Working drawings, shop drawings or full size drawings shall be prepared and submitted by the Contractor to the PMO/Engineer for his approval as specified herein at no extra cost.

The Contractor shall also submit samples or catalogues of materials for approval as specified without extra cost. The PMO/Engineer will check such samples or catalogues for the assurance of compliance with the design concept and the Specifications.

(4) Scaffold and runway

The Contractor shall furnish, erect and maintain during the work as required all scaffoldings, runways, guardrails, and all other temporary constructions as may be necessary for the construction of the works.

(5) Cleaning

The Contractor shall from time to time remove all dirt and rubbish caused by the work from the construction site. At completion of the work, the Contractor shall thoroughly clean the interior and exterior of the buildings.

20200 EARTHWORK

20201 General

Unless otherwise provided herein or directed by the PMO/Engineer, the works under this Clause shall be performed in accordance with the provisions of CHAPTER 1 CIVIL WORKS hereinbefore.

20300 CONCRETE AND FORMWORKS

20301 General

Unless otherwise provided herein or directed by the PMO/Engineer, the works under this Clause shall be performed in accordance with the provisions of CHAPTER 1 CIVIL WORKS hereinbefore.

The type of concrete to be used for the building works shall be of Class A for structures, and Class D for blinding concrete.

The class of concrete formwork to be used shall be of type F1, type F2 and type F3, use of which for various places shall be as directed by the PMO/Engineer.

20400 MASONRY WORKS

20401 Concrete Block Masonry

(1) Materials

Concrete blocks to be used shall be hollow blocks of approved design having exterior dimensions as specified in Mauritian Standard MS 42 – 1986 Specification for Concrete Building Blocks. The concrete blocks shall have a compressive strength of not less than 40 kg/cm2 and an apparent specific gravity, air dried of not less than 1.7.

(2) Concrete block laying

The concrete block shall be laid in straight and struck joints of about 1 cm thick with 1:3 cement mortar.

The concrete block walls shall be reinforced with 9 mm steel bars in 80 cm interval in horizontal and vertical directions. Anchor steel bars shall be preinstalled to the surrounding floor, columns, walls and ceiling at intervals and locations to enable connection to the reinforcement bars. All splices shall be taken 30 times the bar diameter.

The hollows through which the reinforcement bars run shall be thoroughly filled with 1:3 cement mortar.

The wall shall, when large in height and width, be divided into sections with reinforced concrete frames in compliance with the applicable standard or as directed by the PMO/Engineer. This reinforcement work shall be paid separately under pertinent pay items.

Where required to install doors, windows and any other opening in the concrete block wall, reinforced concrete lintels shall be provided. The Contractor shall design the lintel and shall obtain the approval of the PMO/Engineer.

Laying of the concrete blocks shall not exceed 1.2 meters in height per day.

20402 Measurement and Payment

Measurement for payment for concrete block wall shall be made on the basis of the areas in square meters of block walls constructed in accordance with the Drawings and the Specifications and as directed by the PMO/Engineer.

The unit price for concrete block masonry works shall include supplying and placing concrete blocks plus bonding and filling cement mortar, reinforced concrete lintels and any other relevant works required. Reinforcement bars shall be paid for under a separate item.

20500 WATERPROOFING

20501 Bituminous Built-up Roofing

The bituminous waterproof roofing shall be of 3-Ply built-up roofing and 2-Ply built-up roofing for roof and the interior floor respectively applied with the following layers.

3-Ply built-up roofing	2-Ply built-up roofing
- Asphalt primer	- Asphalt primer
- Asphalt compound	- Asphalt compound
- Asphalt felt (1st layer)	- Asphalt felt
- Asphalt compound	- Asphalt compound
- Special asphalt felt (2nd layer)	- Asphalt felt
- Asphalt compound	- Asphalt compound
- Asphalt felt (3rd layer) w/ slag surfacing	

(1) Materials

Asphalt primer shall be factory mixed primer composed of blown asphalt, solvent naphtha and benzine in an approximate weight ratio of 4.5:3.0:2.5.

Asphalt compound shall be of blown asphalt having the following characteristics :

Penetration index	:	15 - 25
Melting point	:	100°C or over
Malleability (Daw Smith 25°C)	:	2 or over

Asphalt felt shall be a bituminous sheeting with a coating of high penetration index asphalt with fabric reinforcement.

The Contractor shall submit specifications sheets and sample of the roofing materials to the PMO/Engineer for approval.

(2) Application

Substrate for the roofing shall be made by applying cement mortar plastering on concrete surface. All external and internal angles shall be made round in a radius of not less than 50 mm.

Asphalt primer shall be applied only on the base cement mortar completely dried at not less than 0.3 l/m^2. Then the first layer of asphalt felt shall be fixed using asphalt compound applied hot at not less than 1.0 kg/m^2. The second and third layers shall be fixed following the first layer with asphalt compound at not less than 1.0 kg/m^2. Top asphalt coat shall be applied not less than 2.0 kg/m^2 over the entire face of roofing.

All laps shall run parallel to the slope of the roof and joints staggered with 50 mm side laps and 75 mm end laps. Care shall be exercised not to leave air bubble inside the layers of roofing.

Roofing work shall be performed by skilled workmen in this trade. The work shall not be performed on a dump or rainy day or in the time considered unsuitable by the PMO/engineer.

20502 Epoxy Waterproofing

Waterproofing by use of hydro epoxy coating shall be no solvent epoxy resins base and equivalent to REZEX EM3 (CR) as produced by Cormix Ltd., P.O. Box 132, Warrington, Cheshire, England. Two coats on prime coat shall be applied. A total dry film thickness shall be 400 microns at least.

20503 Alternative System

The Contractor may propose an alternative waterproofing system upon approval of the PMO/Engineer. The alternative shall in no way be inferior to the one specified above and shall not entail extra cost to the Employer.

20504 Measurement and Payment

Measurement for payment for bituminous waterproofing and epoxy waterproofing works shall be made on the basis of area in square meters of waterproofing performed in accordance with the Drawings and the Specifications and as directed by the PMO/Engineer. The overlap joints shall not be considered in the measurement of the area.

The unit price shall include supplying and applying each type of roofing including caulking with approved caulking materials and any other relevant works required. The substrate cement mortar and water-proof cement mortar plastering shall be paid for under separate items.

20600 TERRAZZO WORKS

20601 Materials

The marble chips to be used for terrazzo works shall be of hard and durable marble and of colours approved by the PMO/Engineer. The grading of the chips shall be as follows:

Percentage (by weight) passing through 12 mm mesh screen 100%
Percentage (by weight) passing through 2.5 mm mesh screen 0%

Colour pigments shall be added to produce the required colour pattern. Samples of terrazzo shall be submitted for approval of the PMO/Engineer.

20602 Application

(1) Terrazzo in-situ

In case the Contractor uses cast-in-situ terrazzo finish instead of the terrazzo tile, the Specifications of work shall be as follows:

The marble chips shall be mixed with white cement paste to a ratio of 1:2.5 in volume. The total thickness of terrazzo in-situ including base mortar shall be 50 mm thick.

The base for the terrazzo finish shall be of cement mortar rendering 18 mm thick performed as specified in plastering works hereinafter.

After sufficient hardening of the finish coat, the surface shall be ground with emery powder ranging from coarse to fine and polished with wax to a luminous and satisfactory finish using appropriate grinding machine or hand tools.

Brass dividing strips, 5 x 16 mm in size shall be installed prior to the application of the base mortar, anchored and set in place to the dimensions and alignment as shown on the Drawings.

(2) Terrazzo tile

Terrazzo tiles and blocks shall be precast to the dimensions as selected by the PMO/Engineer. The method of precasting terrazzo tiles shall be the same as for the terrazzo in-situ described above.

The precast terrazzo tiles shall be laid over a base cement mortar and laid level and plumb as the case may be with butt joints.

After sufficient lapse of time for cement mortar and paste to harden, the terrazzo shall be ground smooth by mechanical means, washed down with water and polished with wax.

20603 Measurement and Payment

Measurement for payment for terrazzo floor, skirting and ledge shall be made on the basis of the area in square meters of floor and the length in linear meters of terrazzo skirting, and terrazzo ledge supplied and laid respectively in accordance with the Drawings and the Specifications and as directed by the PMO/Engineer.

The unit price shall include the base mortar, dividing brass strips and anchors and any other relevant works required.

20700 TILE WORKS

20701 Material

Only first-class quality tiles shall be used in the works. The Contractor shall submit to the PMO/Engineer samples of the tiles for approval.

(1) Ceramic tiles for interior walls

Ceramic tile for interior use shall be 100 x 100 x 6 mm approximately in size. The ceramic tiles shall have glazed surface and round arris. Colours shall be selected by the PMO/Engineer. Different type of ceramic tile may be proposed by the Contractor for approval, but without extra cost.

(2) Porcelain floor tile

Porcelain floor tile shall be 100 x 100 x 10 mm approximately in size and shall have unglazed surfaces. Colours shall be selected by the PMO/Engineer. Different type of floor tile may be proposed by the Contractor for approval but without extra cost.

(3) Porcelain wall tile

Porcelain wall tile shall be 200 x 100 x 12 mm approximately in size and shall have glazed surface. Colours shall be selected by the PMO/Engineer. Different type of wall tile may be proposed by the Contractor for approval, but without extra cost.

20702 Ceramic Tile, and Porcelain Tile

Concrete and/or concrete hollow block surfaces to receive the tiles shall be cleaned free from dirt, oil, grease and other deleterious substances and soaked with clean water prior to application of the rendering cement mortar base.

The rendering cement mortar base for the tile works shall be prepared as specified in plastering works hereinafter.

Porcelain tile for the floors shall be set with 1:3 cement mortar to the level and slope specified. Ceramic tile and porcelain tile for the walls shall be set with 1:3 cement mortar. Joints for ceramic tile for interior shall be 2 mm wide, uniform and true to line and flushed with white cement paste. Joints for porcelain floor and wall tiles shall be 10 mm wide and grouted with cement paste.

After completion of setting, the tile surfaces shall be washed down until clean with plain water or muriatic acid according to the manufacturer's instructions.
Plumbing fixtures and any others to be built in the tile surface shall be installed as tiling work progress.

20703 Measurement and Payment

Measurement for payment for tile works shall be made on the basis of the actual surface areas in square meters covered with each type of tiles supplied and laid in accordance with the Drawings and the Specifications and as directed by the PMO/Engineer.

The unit price shall include all special moldings, bedding cement mortar, joint filling cement paste, bonding adhesives and any other relevant works required.

20800 PLASTERING WORKS

20801 Cement Screed and Plaster

The sand to be used in the cement mortar shall be clean, hard, solid and durable and shall not contain harmful amounts of dust, mud, organic materials or other objectionable matter. The grading of the sand shall be within the following limits.

Classification	Sieve Designation	Percentage by Weight Passing Screen
Scratch coat	5 mm	100 %
	0.15 mm	10 % or under
Finishing	2.5 mm	100 %
	0.15 mm	10 % or under

The mix proportions of the cement mortar shall be as follows:

Substratum	Place of Application	Scratch Coat Cement: Sand	Finish Coat Cement:Sand or Cement:Sand:Lime
Concrete	Floor		1 : 2
	Interior wall	1 : 2	1 : 3 : 0.3
	Ceiling	1 : 2	1 : 0.3
	Exterior wall	1 : 2	1 : 3
	Interior wall	1 : 3	1 : 3 : 0.3
Concrete Block	Interior wall	1 : 3	1 : 3 : 0.3
	Exterior wall	1 : 3	1 : 3

20802 Waterproof Cement Mortar

Waterproof cement mortar shall be applied to canopy, balcony, parapet, eaves and other places as shown on the Drawing or as directed by the PMO/Engineer.

Cement mortar shall conform to the specifications as provided for in this Clause. Waterproof admixture shall be used in the cement mortar in accordance with the manufacturer's recommendations to effect waterproofing. Catalogues of waterproofing admixture shall be submitted to the PMO/Engineer for his approval.

20803 Expanding Grout

An expanding grout shall be used around any pipe passing through a concrete or masonry wall where water may stand on one or both sides of the wall and where the pipe is not embedded in the initially constructed structure. Such grout shall expand upon setting to effect bonding to the concrete and the pipe. An approved expanding agent shall be used and the grout composition shall conform to the manufacturer's instructions.

20804 Application

The surfaces which are to receive a scratch coat shall be roughened, brushed or washed clean, free from all laitance, scum, loose carbonate scale, loose aggregate, dirt and other foreign matter. In case of concrete block or brick surfaces, they shall be sufficiently and uniformly dampened immediately before the application of mortar.

Concrete surface shall be kept thoroughly wet for 24 hours prior to application of mortar. Cement mortar shall be used within 30 minutes from the time of mixing. Retempering will not be permitted.

The rendering for tile work shall be made 18 mm thick and its surface shall be cross scratched. In case of cement mortar finish, the total thickness of scratch and finishing coat shall be 30 mm for the floors, and 20 mm for walls and other places. When the finishing coat is applied, the entire bay of wall or ceiling shall be finished in one operation in order to minimize joint marks. Where expansion and control joints exist in the base structure, provision shall be made to prevent cracking of the cement mortar by inserting galvanized steel expansion beads within the coating thickness in a manner approved by the PMO/Engineer. The finished surface shall be perfectly plumb, level or sloped as the case

may be without any bulging, runs, bruises or stains.

After application of the finishing coat, the surfaces shall be kept continuously damp for not less than 48 hours and then allowed to become thoroughly dry. Moistening shall be started as soon as the surface has hardened sufficiently to prevent displacement or damage.

20805 Measurement and Payment

Measurement for payment for cement mortar plaster, waterproofing cement mortar plaster shall be made on the basis of actual areas in square meters plastered and troweled and for stair curbs on the basis of length in linear meters plastered in accordance with the Drawings and the Specifications and as directed by the PMO/Engineer.

The unit price shall include all necessary materials including admixtures, and any other relevant works required.

20900 PAINTING WORKS

20901 Materials

Paints shall be of the best quality of its kind. The Contractor shall submit catalogues and specifications of all paints to be used to the PMO/Engineer for his approval.

20902 Application

(1) General

All metal components other than galvanized steel shall be prepared and primed in the shop and finish painted after erection. Metal cabinets and machinery shall be prepared, primed and given two coats of paint in the shop and all damaged places shall be cleaned and touched-up after installation is completed.

Metal surfaces shall be cleaned with metal scrapers and wire brush to remove all mill scale, weld spatter, rust and any other deleterious materials. Oil and grease shall be removed by an approved solvent. The surfaces shall be wiped clean of any dust prior to priming. Priming shall be done immediately after cleaning to prevent new rust. Any primed surfaces that show rusting, flaking, powdering or peeling shall be recleaned and repainted.

All wood surface to receive paint shall be cleaned of all dirt, grease, dust or any other deleterious matters. All surfaces shall be thoroughly sanded and all nail holes, cracks and any other defects shall be puttied, re-sanded to a smooth and flush finish. The painted surface shall show a smooth, level and uniform finish, free from any stains and shall be uniform in colour and shade.

Spray painting equipment shall be adequate for the work to be performed and shall have suitable air pressure and paint flow controls. Air lines shall be equipped with moisture and dirt traps. The paint shall be continuously stirred during the painting process. The paint shall be mixed and applied in accordance with the manufacturer's recommendations. The equipment and painting process shall be subject to the PMO/Engineer's approval.

All painting work shall conform to the manufacturer's specifications and instructions.

Painting shall not be done in rain, fog or mist, or at any other time considered unsuitable by the PMO/Engineer.

All the surrounding works shall be protected in a suitable manner from paint drops and overspray. All smeared and damaged surfaces shall be cleaned or repaired to the PMO/Engineer's satisfactions.

Colour shall be later designated by the PMO/Engineer.

(2) Oil paint to metal surfaces

Steel doors, steel louvers and all other miscellaneous steel surfaces shall be painted with one coat of anti-corrosive paint and 2 coats of oil paint. Sufficient time shall be allowed for drying between each new coat.

Galvanized metalwork to be painted shall be first etched with 5% acetic acid and washed clean before priming.

(3) Oil paint to wooden surfaces

Paints shall be applied in 3 coats including one coat of primer paint. Sufficient time shall be allowed for drying between each new coat.

(4) Vinyl emulsion paint to cement mortar and asbestos cement sheet

The cement mortar shall be left to dry for a minimum period of 3 weeks after

application. The vinyl emulsion paint shall be applied in 3 coats including a primer coat. Minimum 12 hours shall be allowed before application of each successive coat.

(5) Acidresistant painting

Acidresistant painting shall be one of the emulsion type synthetic resin paints which has a proven quality of acidresistance.

20903 Measurement and Payment

Measurement for payment for painting work shall be made on the basis of the actual area in square meters of painted surface supplied and applied in accordance with the Drawings and the Specifications and as directed by the PMO/Engineer. The unit price shall include all surface preparation and making good painting after damage by other trades and any other relevant works required.

21000 CARPENTRY AND JOINERY WORKS

21001 Materials and Workmanship

The Contractor shall submit shop drawings of respective work items in this Clause to the PMO/Engineer for his approval.

Timber shall be of suitable kinds for the purposes and the best grade of each kind. Selection of timber shall be subject to the approval of the PMO/Engineer.

All timber shall be well-seasoned and shall be free from large knots, flaws, shakes or blemishes of any kind. Timber with loose, rotten or dead knots will not be accepted. Sawn timber shall have the shape and size shown on the Drawings and twisted or warped materials shall not be used.

All wooden members shall be brought and fixed exactly as shown on the Drawings and planed wherever exposed to view. Wood members not to be painted and having direct contact with concrete shall receive a coat of creosote prior to fixing, while those to be painted or exposed shall be painted with an approved clear type preservative.

(1) Curtain boxes

Curtain boxes shall be fabricated and installed using 25 mm thick wood board with adequate ribs. They shall be carefully fixed to the walls above windows and ceiling joists. The surfaces of the blind boxes shall be coated with oil paint.

(2) Wooden door frames

All wooden door frames shall be made of hard wood and mortise jointed. The door frames shall be moulded as shown on the Drawings or as directed by the PMO/Engineer, and sanded and putty applied to a smooth surface to receive oil paint.

21002 Measurement and Payment

Measurement for payment for curtain boxes shall be made on the basis of the nominal lengths in linear meters of curtain box installed in accordance with the Drawings and the Specifications and as directed by the PMO/Engineer. No payment shall be made for the wooden door frames;

the cost for these shall be included in door leaves.

The unit price for curtain boxes shall include supplying and fixing of curtain box including fixing device and any other relevant works required. Painting finish to the wooden surfaces shall be paid for under separate items.

21100 INTERIOR FINISHING WORKS

21101 Materials

All materials shall be of the best quality and shall comply with the applicable standards. The Contractor shall submit samples and/or catalogues of the finishing materials to the PMO/Engineer for his approval.

(1) Rockwool acoustic tile

Rockwool acoustic tiles shall be of a product of plaster and rockwool having a fissued surface simulating travertine stone with a white finish, and shall be approximately 300 mm x 600 mm x 12 mm in size.

(2) Asbestos cement sheet

Asbestos cement sheets shall be of hard asbestos flat sheet, 6 mm thick.

(3) Vinyl floor tile

Vinyl floor tiles shall be of 300 mm x 300 mm x 2 mm thick.

(4) Vinyl strip base

Vinyl strip base to skirting shall be of 100 mm high.

21102 Installation

(1) Rockwool acoustic tile

Ceiling suspension system shall be constructed of wood, steel or aluminium complete with anchors, hangers, clips, main runners furring strips, and such other accessories as ceiling moulding.

Main runner shall be provided at intervals of approximately 90 cm, installed with allowance for adequate camber. They shall be designed for ceiling loads of 70 kg/m2.

Furring strips shall be provided at intervals of 30 cm or according to the ceiling material. Adequate reinforcing and metal training shall be provided for mounting the lighting fixtures and ceiling access holes.

Ceiling tiles shall be securely fixed to the furring strips with galvanized screws true to level and line. Ceiling trims shall be of plastic moulding and fixed to the wall before cement plastering is carried out. The entire suspended ceiling shall be to the level shown on the Drawings with adequate camber and shall not have a deviation in levels and lines of more than 3 mm in 4 m bay.

The ceiling tile shall be so arranged that the fractional tile cut to fit the room is minimum. Ceiling access hole shall be provided in the rooms as directed by the PMO/Engineer. The

access hole covers shall match the surrounding ceiling and continuity of the ceiling pattern shall be maintained as much as possible.

(2) Asbestos cement sheet

Asbestos cement sheet shall be of hard asbestos flat sheets, 6 mm thick and shall conform to JIS A5403 or approved equivalent. The asbestos cement sheet ceiling shall include the complete suspending ceiling system same as specified for the rockwool acoustic tile in this Clause. The sheets shall be fixed securely to the ceiling joist with stainless flat head screws. Joints shall be of open joints 5 mm wide, straight and uniform. Ceiling access holes shall be provided in the same manner as specified for the rockwool acoustic tile. Surface of the sheet shall be finished with vinyl emulsion paint as shown on the Drawings.

(3) Vinyl floor tile

Floor surfaces upon which tiles are to be placed shall be covered with cement plaster bed 30 mm thick bonded to the structural concrete as specified in Plastering Works hereinbefore. The plastered surfaces shall be clean and free from dust, oil and moisture. The back surfaces of the tiles shall be clean.

Vinyl floor tile shall be applied with adhesives upon the primed surface in such a manner that adjacent tiles are butted tightly together to form straight continuous joints and uniform regular patterns as shown on the Drawings or as prescribed by the PMO/Engineer. The colour and pattern of tile shall be selected by the PMO/Engineer.

Adhesive for applying tiles shall be furnished in sealed containers bearing the manufacturer's label and instructions for application.

(4) Vinyl strip for base

Vinyl strip shall be applied on a smooth surface, dry and clean. Adhesive shall be applied and vinyl strip firmly placed with its toe in contact with the finished floor. The base shall then be rolled with a roller. External and internal corners shall be installed with preformed pieces.

21103 Measurement and Payment

Measurement for payment for rockwool acoustic tile, and asbestos cement sheet ceilings shall be made on the basis of the actual areas in square meters of ceiling installed in accordance with the Drawings and the Specifications and as directed by the PMO/Engineer. Holes made for lighting fixtures, air diffusers and the like shall not be deducted from the area measurement.

The unit price shall include supplying and installing the ceiling materials plus complete suspending system, the provision of access holes and covers and any other relevant works required. Painting finish for the asbestos cement sheet shall be paid for under a separate item.

Measurement for payment for vinyl floor tile and vinyl strip to skirting shall be made on the basis of the actual areas in square meters of vinyl floor tile and the length in linear meters of vinyl strip applied respectively in accordance with the Drawings and the Specifications and as directed by the PMO/Engineer.

The unit price shall include supplying and applying the vinyl floor tile or vinyl strip plus adhesive and other relevant works required.

21200 WOODEN DOORS

21201 General

Before manufacturing wooden doors, the Contractor shall submit shop drawing showing details of the doors to the PMO/Engineer for his approval.

All wood surfaces shall be sanded and putty applied to smooth surfaces to receive oil painting or varnish.

21202 Wooden Door Leaves

All wooden door leaves shall be flush type, 40 mm thick, with panes or louvers as shown on the Drawings and shall be faced with 6 mm thick first-grade waterproof plywood.
The plywood shall be covered with lauan lamina, putty polished and oil painted or varnished. Panes or louvers, if provided, shall be fixed with adequate beads.

21203 Hardware

The Contractor shall supply and install the hardware for the wooden doors as listed in the Drawings.

The Contractor shall submit catalogues or samples of the hardware to the PMO/Engineer for his approval.

The hardware shall comply with the following requirements:

Hinges	Bronze or stainless steel, 13 cm in approximate size, 3 hinges for each door leaf
Knobs or lever handle	Stainless steel or bronzed aluminium
Lock sets	Bronze, cylindrical lock, 3 sets of key to be furnished
Door closers	Cast aluminium body, oil and spring activated rack and pinion with 90 degree stop device
Push and Pull	For toilets door, plastic made 15 cm x 25 cm in approximate handle size

The Contractor shall supply master key set as directed by PMO/Engineer.

21204 Measurement and Payment

Measurement for payment for wooden doors shall be made on the basis of the actual total area in square meters of door leaves supplied, fabricated and fixed in accordance with the Drawings and the Specifications and as directed by the PMO/Engineer.

The unit price shall include supplying and installing wooden door leaves plus door frames, hardware and any other relevant works required. Painting finish and glazing shall be paid for under separate items.

21300 STEEL DOORS AND FRAMES, AND ROLLING SHUTTER

21301 General

All steel doors, frames and hardware shall be of first-class quality.

The Contractor shall submit shop drawings showing details of various parts, method of anchoring and any other pertinent details to the PMO/Engineer for his approval.

Before placing orders, the Contractor shall submit catalogues or samples of hardware to the PMO/Engineer for his approval.

All exposed surfaces to view shall be oil paint finished.

21302 Hollow Steel Door Leaves

Hollow steel door leaves shall be fabricated of cold rolled steel sheet. The sheet thicknesses shall be as follows:

Panel	1.6 mm
Stiffener plate and anchor plates	2.3 mm

The door leaves shall be full flushed seamless panel type, 40 mm in thick unless otherwise specified. All four edges shall be sealed and ground smooth.

Door leaves shall be adequately reinforced for rigidness and for fixing hardware.

Where shown on the Drawings, panes and louvers shall be provided with metal beads.

21303 Steel Door Frames

Door frames shall be formed of cold rolled steel sheet. The sheet thickness shall be as follows unless otherwise specified.

Frame	1.6 mm
Architrave	1.2 mm
Threshold	2.3 mm

Door frames shall be profiled accurately to details and dimensions shown on the shop drawings approved by the PMO/Engineer. Door frames shall be reinforced, drilled and tapped to receive hardware and shall be provided with rubber bumpers.

Door frames shall be fixed to the wall by means of welding to the pre-embedded anchors. Perimeters of door frames facing outdoor shall be securely caulked with approved caulking material.

21304 Steel Rolling Shutter

Steel rolling shutter shall be manual operative type as shown on the Drawings.
The shutter shall be curtain type composed of slats, guide tracks, rolling drum and hood.

Specifications for the various components shall be as follows:

Slat	Interlocking type, steel plates 1.5 mm thick, designed against a wind velocity of not less than 25 m/sec.

Guide track	2.3 mm thick formed stainless steel plates, depth 60 mm, with safety stop at a height of 2.2 m above the floor, anchored securely to the concrete jambs.
Hood	1.6 mm thick steel plate with adequate reinforcement and inspection door.
Rolling drum	Counterbalanced by spring

21305 Hardware

Hardware for the steel door shall comply with the requirements specified on the Drawings. The Contractor shall submit catalogues or samples to the PMO/Engineer for his approval.
Each door shall be provided with the following hardware:

Floor hinge	Cast iron body with stainless steel cover, oil and spring activated rack and pinion with 90 degree stop device
Hinge	Pivot hinge, 2 pieces for each door leaf
Knob or lever handle	Stainless steel
Lock sets	Bronze, cylindrical lock, 3 sets of key to be furnished
Door bolt	Bronze, surface or flush type
Door closer	Cast aluminium body, oil and spring activated rack and pinion, with 90 degree stop device.

The Contractor shall supply master key set as directed by the PMO/Engineer.

21306 Measurement and Payment

Measurement for payment for steel doors shall be made on the basis of the total area in square meters of door leaves fabricated and fixed in accordance with the Drawings and the Specifications and as directed by the PMO/Engineer.

Measurement for payment for steel rolling shutter shall be made on the basis of the area of shutter opening in square meters installed in accordance with the Drawings and the Specifications and as directed by the PMO/Engineer.

The unit prices for steel doors and steel rolling shutter shall include supplying and installing each item plus frames, louvers, hardware, caulking materials and any other relevant works. Painting finish and glazing will be paid for under separate items.

21400 ALUMINIUM DOOR, WINDOWS AND LOUVERS AND FRAMES

21401 General

All aluminium doors, windows, louvers and frames shall be of first-class quality.
The Contractor shall submit shop drawings showing details of various parts, method of anchoring and any other pertinent details for approval of the PMO/Engineer. Before placing orders, the Contractor shall submit catalogues of hardware to the PMO/Engineer for his approval.

21402 Materials and Workmanship

All aluminium members shall be of extruded aluminium and fabricated pieces before delivery shall be protected with strippable plastic. The plastic shall be removed after the major construction work has been completed.

Doors, windows, and louvers shall be furnished with frames, fixing lugs and glazing beads.

Prior to installation of doors, windows and louvers, the Contractor shall ensure that the surface of the concrete or steel to receive the frames are free from all loose and foreign material. The frames shall be set true to the planes without warping and shall be fixed in place through the fixing lugs by means of welding to the pre-embedded anchors. Spaces between the frames and wall shall be grouted with cement mortar and outdoor perimeters sealed with approved caulking materials.

Insect screen shall be fabricated of aluminium wires secured in frames to the inner side of windows and louvers by means of spline. Screen unit shall be removable and rewirable.

The hardware shall comply with the following requirement:

Floor hinge	Cast iron body with stainless steel cover, oil and spring activated rack and pinion with 90 degree stop device.
Push and pull handle	For entrance door, stainless steel, 20 cm x 20 cm approximate in size.
Hinge	Bronze or stainless steel, 13 cm in approximate size, 3 hinges to each door leaf (less than 2.1 meters high)

Knob or lever handle	Stainless steel or bronzed aluminium
Lock set	Bronze, cylindrical lock, 3 sets of key to be furnished
Door closer	Die-cast aluminium body, oil and spring activated rack and pinion with 90 degree stop device
Door bolt	Bronze, surface or flush type
Sash fastener and handle	Cast aluminium

The Contractor shall supply master key set as directed by the PMO/Engineer.

21403 Measurement and Payment

Measurement for payment for aluminium doors, windows, and louvers shall be made on the basis of the areas in square meters of interior opening of the frames supplied, fabricated and installed in accordance with the Drawings and the Specifications and as directed by the PMO/Engineer.

The unit price shall include insect screen, hardware, caulking materials and any other relevant work required.

21500 GLAZING WORKS

21501 Glass

Door and window panes shall consist of the following types of glass:

a. Plate glass – 5 mm thick
b. Plate glass – 3 mm thick
c. Figured glass – 4 mm thick
d. Wired glass – 6.8 mm thick

The brand and quality of glass shall be subject to the PMO/Engineer's approval.

21502 Glazing

All glasses shall be accurately cut to fit in the frames with 3 mm clearance all around. Glasses in metal windows and door leaves shall be set in glazing mastic applied on all four sides for the full length using spacer shims or with vinyl splined glazing bead as recommended by the manufacturer. Panes for wooden frames shall be fixed with wood stops.

All door and window panes shall be cleaned and polished when the building work is completed.

21503 Measurement and Payment

Measurement for payment for glazing shall be made on the basis of the actual areas in square meters of openings glazed under each category in accordance with the Drawings and the

Specifications and as directed by the PMO/Engineer.

The unit price shall include supplying and installing each type of glasses plus glazing mastic, beads, shims and any other relevant works required.

21600 MISCELLANEOUS METAL WORKS

21601 Materials

All materials to be incorporated in the works shall be of the best of its kind.

Catalogues or samples of stair nosing, roof drains and floor drains shall be submitted to the PMO/Engineer for approval. The Contractor shall prepare and submit shop drawings showing details of parts, assemblies, components, supports and connections to the PMO/Engineer for his approval. The work shall be shop fitted or shop assembled where possible.

Wherever necessary, metals shall be insulated to prevent electrolysis due to contact with dissimilar metals. Insulation shall be made by means of bituminous paint or other approved means.

21602 Materials and Installation

(1) Roof and floor drains

Roof and floor drains shall be of cast iron body, heat coated with asphalt. Care shall be exercised in accommodating the surrounding waterproofing works to prevent any damage

to the water proofing membrane. Caulking shall be applied as required.

Floor drains shall be fitted with flat removable chromium plated brass grate. Roof drain grates shall be convex in profile at least as high as the pipe diameter and the total area of the openings of the grate shall be not smaller than 1.5 times the cross-section area of the drain pipe. Grates shall be fixed with noncorrosive screws.

Roof drains shall have two flanges. The bottom flange shall be integral with the drain body and shall be set to coincide with the waterproof membrane or with top surface of the surrounding concrete. The top flange shall be screwed to the bottom flange and shall be set lower than the surrounding roof finish. The two flanges shall be used to clamp the waterproof membrane.

(2) Stair nosings

Stair nosings shall be of stainless steel with serrated surface or embedded with plastic tire for non-slip. The stair nosing shall be approximately 40 mm wide and installed on the full width of each stair tread. Anchorage shall be provided to the under side of the nosing.

(3) Steel handrails

Steel handrails shall be provided for the stairs and other places as shown on the Drawings. Steel handrails shall be fabricated of mild steel structural pipes. Embedded part of blusters shall be welded to the reinforcement bars in the structure. Oil paint finish shall be applied to all exposed steel surfaces.

(4) Steel ladders and steel caged ladders

Steel ladders shall be fabricated and installed to concrete structure as shown on the Drawings. Anchor plates shall be embedded in concrete at the proper locations while the concrete is placed, or recesses shall be left in the concrete for anchoring which shall be grouted with cement mortar after anchoring. Oil paint finish shall be applied to all exposed steel surfaces.

(5) Cover for expansion joints

Covers for expansion joints on roof shall be of stainless steel plate 0.5 mm thick or copper plate 20 oz. Cover plates and backing and fixing materials shall be neatly fabricated so as to prevent water infiltration, to allow structural movement and also to provide a satisfactory finish appearance.

(6) Cable trench covers

Cable trench covers for floor cable duct shall be of checkered steel plate 4.5 mm thick unless otherwise specified. Bearings shall be fabricated of steel angles with floor trimmings and anchorages. The checkered steel plates shall be properly reinforced with steel angles depending on the size of the floor duct, provided with lifting devices and set flush with the floor finish. Concealed surfaces shall be anti-corrosive painted and exposed surfaces to view oil paint finished.

(7) Steel grating hatch cover

Steel grating hatch covers shall be provided where shown on the Drawings or directed by the PMO/Engineer. The grating shall be galvanized and withstand a static uniform load

of 300 kg/m^2. The grating, and support beams shall be hot-dip galvanized.

(8) Coping metal

Coping on roof shall be of factory-made aluminium, accompanied with purpose-made backing and fixing metals. The Contractor may propose alternative metal coping upon approval of the PMO/Engineer.

(9) Chemical retention cage

Chemical retention cage shall be constructed of stainless steels as shown on the Drawing. Stainless steel to be used shall be of JIS SUS316 or equivalent.

21603 Measurement and Payment

Measurement for payment for roof and floor drains, and stainless steel chemical retention cage shall be made on the basis of number of the item in pieces installed in accordance with the Drawings and the Specifications and as directed by the PMO/Engineer.

Measurement for payment for stair nosing, steel handrails, steel ladders, expansion joint covers and aluminium copings shall be made on the basis of nominal lengths in linear meters of each item installed under each category in accordance with the Drawings and the Specifications and as directed by the PMO/Engineer. Balusters and intermediate rails shall not be counted in the measurement of steel handrails.

Measurement for payment for cable trench covers and steel grating hatch covers shall be made on the basis of the area in square meters of checkered steel plates and steel gratings respectively

installed in accordance with the Drawings and the Specifications and as directed by the PMO/Engineer.

The unit price for each item shall include supplying and installing each item plus any other relevant works required. Paint finish will be paid for under a separate item.

21700 MISCELLANEOUS WORKS

21701 Materials

Each item shall be of the best of its kind in design, quality and appearance and free from any defect that would impair strength, durability or appearance. Catalogues and/or shop drawings shall be submitted to the PMO/Engineer for his approval.

21702 Materials and Installation

The work shall be fitted and assembled in the shop as much as possible. The work shall be erected true and straight, accurately fitted with tight joints and intersections. All works shall be reinforced where required. The rims shall be neatly and accurately mitred. Where screws are used, the heads shall be concealed.

(1) Kitchen units

Kitchen sink units shall consist of a sink unit, a range table unit and a suspended cupboard unit having dimensions as shown on the Drawings. The counter tops of the unit shall be made of stainless steel not less than 0.6 mm thick. The remaining parts shall be of

wooden fabrication finished with melamine or polyester resin. Metal flashing shall be provided along the backsprash. The metal flashing shall be of stainless steel sheet 0.6 mm thick and securely fixed to the wall.

(2) Downspouts

Downspouts shall be of polyvinyl chloride or steel pipe. The downspouts shall be securely fixed to the walls with steel ring supports at 150 cm intervals.

(3) Laboratory table and workbench

Laboratory tables in Operation Building and workbenches in Workshop shall be of factory-made ones constructed of steel frames and hard plastics sheet covered desk decks. Each table and workbench unit shall be provided with drawer unit. Laboratory table shall be provided with build-in sinks, and shelves as shown on the Drawing. The Contractor may propose an alternative tables and workbenches upon approval of the PMO/Engineer.

(4) Prefabricated partition

Partition in Laboratory of Operation building shall be of prefabricated steel partition, glazed on its upper half. Its height shall be 2.1 m. Glass shall be figured glass and steel surfaces oil painted.

21703 Measurement and Payment

Measurement for payment for kitchen sink unit and rubber bumper shall be made on the basis of the number of the unit and bumper in set and piece respectively installed in accordance with

the Drawings and the Specifications and as directed by the PMO/Engineer.

Measurement for payment for downspouts and prefabricated partition shall be made on the basis of the nominal lengths of downspout and partition wall in linear meters installed in accordance with the Drawings and the Specifications and as directed by the PMO/Engineer.

Measurement for payment for laboratory table and workshop work bench shall be made on the basis of the frontal length of each item in linear meters installed in accordance with the Drawings and the Specifications and as directed by the PMO/Engineer.

The unit price shall include supplying and installing each item plus all built-in items, necessary fixing devices, calking where required and any other relevant works required.

21800 PLUMBING WORKS

21801 General

The works under this Clause shall comprise water supply, waste water and sewage drainage works for the buildings.

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, at no additional cost to the Employer.

The general arrangement of the plumbing shall be as indicated on the Drawings. Detailed drawings of proposed departures due to actual field conditions or other causes shall be submitted

for approval.

Materials and equipment installed in the plumbing system shall be suitable for the pressures and temperatures encountered. Installation shall be as required by applicable national plumbing code of the country and local regulations around the site and as specified herein.

Installation shall be accomplished by workmen skilled in this type of work.

(1) Shop drawings and working drawings

At least 60 days prior to starting installation of any materials or equipment, the Contractor shall submit to the PMO/Engineer for his approval the following shop or working drawings:

- Layout drawings of equipment including list of equipment and materials to be incorporated,
- Details of piping and valving,
- Details of sleeves for piping,
- Details of supports, hangers, attachments and anchoring,
- Details of foundation for equipment,
- Detailed layout of electric wiring and conduiting,
- Complete electrical connection diagrams, and
- Other drawings as required by the PMO/Engineer.

(2) Data and samples

The Contractor shall submit for approval of the PMO/Engineer a complete list of materials and equipment to be incorporated in the works under this Clause including sufficient descriptive materials such as catalogues, diagrams, performance curves, charts, layout

drawings and other data published by the manufacturer to demonstrate the conformance to the Specifications and the Drawings.

(3) Operation and maintenance manuals

Six complete sets of operation and maintenance manuals for the plumbing system shall be furnished as specified hereafter. The manuals shall be furnished at the time of performance tests of the system. The manuals shall include but not limited to the following:

(a) Explanation of system

- General description of system including function, design conditions, system design and equipment incorporated,
- Schematic diagrams of piping including equipment, valves and controls,
- Schematic diagram of electric power supply and controls, and
- Layout plan of equipment.

(b) Operation and maintenance instructions

- Method of operation including procedures for safe starting and stopping of equipment, preventive procedures, and checking methods,
- Manufacturer's instructions on each piece of equipment including lubrication instructions,
- Daily, weekly, monthly and yearly inspection items on each piece of equipment and systems, and
- Method of finding causes of breakdown of each piece of equipment and systems and countermeasures to be taken.

(c) Manufacturer's bulletins

- Manufacturer's specifications, shop drawings and catalogues of each piece of equipment.
- Manufacturer's certifications
- Any guarantee, test data and engineering data furnished by the manufacturers.

(d) Spare parts list

- List of spare parts and consumables furnished with the equipment as standard appurtenances as required by the Specifications

(e) Service and maintenance organizations

- Name and address of nearest recommended service and maintenance agent who can practically be addressed by the Employer at the time of breakdown of an equipment.

(4) Attachments and spare parts

The Contractor shall furnish with each piece of equipment standard attachments and spare parts which the manufacturer supplies under normal commercial transactions. In addition to these the Contractor shall furnish spare parts, consumables or stand-by equipment as specified hereinafter. The Contractor shall also furnish a complete list of spare parts as recommended for operation of each piece of equipment for a period of one year with current prices and source of supply.

(5) Tools

The Contractor shall provide sufficient special tools as recommended by manufacturers for field maintenance of the system. One complete set shall be provided at no extra cost to the Employer.

(6) Field instructions

Upon completion of the work, the services of one or more instructors shall be provided by the Contractor for a total period of not less than 2 days to instruct the representative of the Employer in operation and maintenance of the equipment and the systems. These field instructions shall cover all the items contained in the bound instructions as specified for operation and maintenance manuals, and all costs for the services shall be borne by the Contractor.

(7) Tests

The Contractor shall submit his proposed testing programs and procedures at least 2 weeks prior to the scheduled tests and obtain the PMO/Engineer's approval. All tests shall be conducted in the presence of the PMO/Engineer. Any materials, equipment, instruments, personnel, water and electricity required for the tests shall be provided and all expenses thereof shall be borne by the Contractor.

Accurate data of each test shall be recorded and reports of test data shall be submitted.

(8) Floor, wall and ceiling escutcheons

Escutcheons shall where directed by the PMO/Engineer be provided at finished surfaces

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

(9) Foundation for equipment

All foundations for equipment shall be designed at the responsibility of the Contractor. Loading data of the equipment shall be submitted to the PMO/Engineer as required for him to check the structural strength of the buildings. All costs for foundations including grouting and plastering on all exposed faces of concrete with cement mortar shall be included in pertinent pay items in this Clause, except the concrete, formwork and re-bar works which shall be paid for under separate pay items.

21802 Plumbing Materials and Installation

(1) General

All pipes, fittings and fixtures shall be of the kind, grade, type and qualities as shown on the Drawings and as specified.

All pipes shall be jointed with fittings compatible with the pipe and of the suitable type for the intended service.

Union joints shall be properly provided in piping to allow disassembly of the piping for maintenance services or for any modification of the system.

Flanges shall be provided for pipes 75 mm in dia. and larger. The flanges shall be compatible with and shall have the same rating as the companion flange of the valve or the fittings. Full face rubber gaskets shall be provided to all flanged joints.

All piping shall be fitted and assembled to introduce minimum stress to the pipe and fittings. All pipe shall be supported where shown on the Drawings and as required. Polyvinyl chloride (P.V.C.) pipe shall be supported at the spacing recommended by the pipe manufacturer.

The same standard of thread shall be used throughout the works.

All piping to be embedded shall be tested and approved by the PMO/Engineer prior to being embedded.

Sleeves or check-outs shall be provided where pipe passes through concrete structure. The space shall be filled or caulked with suitable materials. Where pipe passes through a wall or floor where watertightness is required, the space shall be filled with yarn and lead or with approved expanding grout.

Cleanout and manhole shall be provided as shown on the Drawings and as directed by the PMO/Engineer.

All pipes embedded in the ground shall be at the pipe top minimum 30 cm below the grade where no heavy traffic is expected and minimum 90 cm below the grade crossing the road and where heavy traffic is expected. Pitch of the pipe line shall comply with the applicable code, regulations and as directed by the PMO/Engineer.

Change in pipe size shall be made with reducing fittings, use of bushings will not be allowed.

Change in direction shall be made with fittings except that bending of galvanized steel pipe 100 mm and smaller will be permitted, provided a pipe bender is used and wide sweep bends are formed. The center line radius of bends shall not be less than 6 times the diameter of the pipe. Bent pipe showing kinks, wrinkles, flattening or other malformations will not be accepted.

Exposed piping shall be run parallel with the lines of the buildings unless otherwise indicated.

Connections between ferrous and nonferrous metallic pipe installed underground shall be made with dielectric unions or flanges.

(2) Pipes

(a) PVC pipes

Polyvinyl chloride pipes shall conform to JIS K-6741 and shall be laid and jointed in accordance with the manufacturer's instructions and to the PMO/Engineer's approval.

(b) Galvanized steel pipes

Water pipes shall be of standard weight galvanized screwed and socketed pipe conforming to JIS-G-3454 and G-3452.

Threaded joints shall be sealed with an approved graphite compound or with equivalent tape applied to the male threads only.

(3) Valves

Gate valves and check valves 50 mm in dia. and smaller pipe shall be of brass or bronze construction. Valves 65 mm in dia. and larger in the pipe line shall have cast iron body and brass trim. Valves 75 mm in dia. and larger shall be flanged.

Gate valves shall be of solid wedge disc type and shall have rising stem or non-rising stem. Check valves shall be horizontal swing type having a lightweight brass disc. Globe valves shall have replaceable resilient plugs and shall have rising stem. Globe valves for use in regulating flow shall have replaceable seats.

Air vent valves shall be either float type, ball type or combined float and heat sensing or diaphragm type to be selected according to the service intended.

All valves throughout this Clause shall be of the same manufacture in principle.

(4) Unions, hose faucets

Unions on ferrous pipe 50 mm in diameter and smaller shall be malleable iron zinc-coated. Unions shall not be concealed in walls, ceilings or partitions.

Hose faucets shall be brass or bronze with male inlet threads, hexagon shoulder and hose connection.

(5) Flexible joints

The flexible joint shall be either of the following:

(a) a rubber tube type formed with a flexible reinforced rubber tube with bolted flanges and split backing flanges for attachment to the pipe.

(b) a bellows type formed with copper or stainless steel, activated by internal pressure and retained by flange rings and tension lug bolts.

(6) Plumbing fixtures

Plumbing fixtures shall be obtained from a reputable supplier and the Contractor shall submit catalogues to the PMO/Engineer for his approval.

Generally, all fixtures except water closets shall have the water supply above the rim. Angle stops, straight stops, stops integral with the faucets and the like for supplies shall be furnished and installed with fixtures. Exposed fixture trimming and fittings shall be chromium-plated or nickel-plated brass with polished, bright surfaces.

Urinal screen shall be provided where a urinal abuts another urinal or lavatory sink on either side. The screen shall be of vitreous china, wall mounted.

(a) Fixture connections and support

Where space conditions will not permit standard fittings in conjunction with the cast iron floor flange, soft lead tubes shall be provided. Connections between earthenware fixtures and flanges on soil pipe shall be made

absolutely gas-tight and watertight with a closet-setting compound or with a neoprene gasket and seal. Bolts shall be equipped with chromium-plated nuts and washers.

Wall-hung fixtures shall be fastened to the wall by through bolts where appearance of the bolts is not objectionable. For solid concrete or masonry and where through bolting is objectionable, fixtures shall be fastened with machine-bolt expansion shields or stud type expansion bolts. For concrete,masonry unit construction, fixtures shall be fastened with through bolts or toggle bolts as required. Exposed bolt heads in finished areas shall be hexagonal. Exposed nuts shall be chromium-plated hexagonal cap nuts. Washers shall be painted or chromium-plated to match bolt heads or nuts.

(b) Connections to equipment and fixtures

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 valve to enable isolation of the item for repair and maintenance without interfering with operation of other equipment or fixtures.

(7) Traps

Each fixture, floor drain 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. Traps installed on cast iron soil pipe shall be cast iron. Traps installed on steel pipe or copper tube shall be recess-drainage pattern, or tube type. Traps for

acid-resisting waste shall be of the same material as the pipe.

(8) Pipe cleanouts

Pipe cleanout shall be the same size as the pipe except that cleanout plugs larger than 100 mm will not be required. A cleanout installed in connection with cast iron soil pipe shall consist of a long-sweep 1/4 bend or one or two 1/8 bends extended to the place indicated.

Cleanouts in connection with other pipe, where indicated shall be T-pattern, 90-degree branch drainage fittings with screw plugs. Cleanout tee branches with screw plug shall be installed at the foot of soil and waste stacks. Cleanouts on pipe concealed in partitions and walls and where installed in finished floors subject to foot traffic shall be provided with chromium-plated cast-brass covers secured to plugs.

(9) Pipe insulation and vapor barrier

Exposed water supply and drainage pipes shall be insulated.

(a) Insulation material

The insulation material shall be fibrous glass or mineral fiber. The insulation thickness shall be as indicated in the following table for mineral fiber and fibrous glass. Exposed insulation in traffic area shall be fitted with a metal jacket to protect the insulation.

Mineral Fiber and Fibrous Glass

Minimum Thickness in mm

Range of temperature degree C	6 thru 32	40 thru 75	80 thru 125	150 thru 250
Above 10	18	18	38	38
10 to 0	25	25	38	38
0 to −15	38	50	50	50
−15 to −10	38	50	65	65

(b) Vapor-Barrier Jacket

The insulation shall be provided with field-applied or factory-applied non combustible vapor-barrier jacket. The jacket shall consist of lamination of aluminium foil glass fiber reinforcement and kraft paper where exposed to view, and where concealed the kraft paper may be omitted. The kraft paper shall be enamel painted.

(c) Application

After pressure tests have been completed in the piping system, insulation shall be applied to the pipe with end joints tightly butted and the vapor-barrier jacket lapped not less 38 mm at longitudinal joint and adhered with adhesive. At circumferential laps, a 75 mm wide strip of jacketing material shall be applied and adhered with the adhesive. On jacket facing to receive

finish painting, the aluminium foil shall not be exposed.

Insulation through Hangers and Sleeves

The insulation shall be continuous through pipe hangers and pipe sleeves.

Flanges, Union, Valves, Anchors and Fittings

Unless otherwise indicated, all flanges, union, valves, anchors and fittings shall be insulated with factory–premolded, or pre–fabricated or field–fabricated segments of insulation of the similar material and thickness as the adjoining pipe insulation.

(d) Piping Exposed to Weather

Piping exposed to weather shall be insulated as specified above for applicable service except thickness required shall be double that specified. The exposed piping shall be finished with 0.4 mm thick corrugated, smooth or embossed aluminium sheet with factory fabricated "Z" type longitudinal joints or field applied seam joints, lapped not less than 50 mm at butt joints.

The joints shall be properly constructed to shed water or otherwise sealed with adhesive compound. Where jacketing abuts an uninsulated surface the joint shall be sealed with weatherproof compound. Fittings and other irregular surfaces shall be protected with two coats of weatherproof coating compound with glass tape embedded between coats. The total thickness of the dry film shall be 3 mm minimum. In lieu of glass tape covering for elbows factory fabricated aluminium sheetmetal elbows may be provided.

The metal thickness shall be not less than 0.4 mm.

When steel pipes and fittings except for cast iron pipe are buried in the ground, they shall be insulated with either of the following with approval of the PMO/Engineer:

(i) Asphalt with jute

(ii) Glasswool cloth impregnated with waterproof insulation compound

(iii) Vinyl tape with adhesive

(10) Pipe hangers, inserts and supports

The Contractor shall submit to the PMO/Engineer for his approval detailed drawings of the type of inserts, hangers and supports for the piping he proposes to provide.

The location of hangers and supports shall be coordinated with the structural work to assure that structural members will support the intended load.

Hangers and supports shall be provided at intervals specified below, at locations not more than 1.0 m from the ends of each runout and not over 30 cm from each change in direction of piping. Hangers shall be adjustable.

Vertical cast iron and steel pipe shall be supported at each floor, or at intervals of not more than 4.5 m and at not more than 2.5 m from end of riser. Horizontal cast iron pipe shall be supported near each hub and hubless joint.

Horizontal steel pipe shall be supported at not more than the following intervals:

Pipe dia.	Interval
Ø20 – Ø25 mm	1.8 m
Ø32 – Ø40 mm	2.0 m
Ø50 – Ø80 mm	3.0 m
Ø90 – Ø150 mm	4.0 m
over Ø200 mm	5.0 m

Underground piping shall be laid on a firm bed for its entire length, except where support is otherwise provided.

(11) Painting

All hangers, supports and other iron works shall be painted with one coat of anticorrosive primer and with two coats of oil paint. All galvanized steel pipes exposed to view shall be painted with two coats of oil paint. Colour code shall be as directed by the PMO/Engineer.

(12) Testing of pipe lines

The Contractor shall test all pipe lines as directed by and in the presence of the PMO/Engineer. If the pipe fails in test, the Contractor shall repair, replace and retest the piping until being accepted by the PMO/Engineer. All piping system shall be flushed clean before testing.

(a) Pressure testing of water service pipe

Pipes shall be subject to a hydraulic pressure test of 5 kg/cm2.

If piping is tested in sections, temporary cap shall be fitted. Each section shall be slowly filled with water and air inside the pipe shall be carefully expelled.

For acceptance, the test pressure shall remain constant for one hour without additional water.

(b) Testing of sewage and waste water pipe

No pipe shall be covered or concealed before it is tested. If any sections of pipe lines are tested, the Contractor shall obtain approval of the PMO/Engineer.

All openings and pipe ends shall be securely plugged and filled up with water up to the top of the highest opening. This water shall remain at the same level for 2 hours.

All pipes shall also be inspected visually to ensure that there is no projections in the pipe and the pipe line is straight and void of abrupt kinks. At least three–quarter of the pipe opening of any sections between manholes shall be visible when viewed from opposite end of the pipe section.

Exposed pipes shall further be subject to a leakage test. Leakage tests shall be made after a minimum of 24 hours after the pipe has been filled with

water. No leakage shall be found for duration of another 2 hours on the pipe line.

21900 AIR CONDITIONING AND VENTILATION SYSTEMS

21901 General

(1) Codes and standards

All equipment, materials and installation shall comply with the following standards where applicable in so far as they do not conflict with what specified herein.

(a) Japanese Industrial Standard (JIS)
(b) Heating, Air Conditioning and Sanitary Standard in Japan (HASS)
(c) Other approved standards or codes

The Contractor shall obtain the approval of the PMO/Engineer if he proposes to deviate from the above codes or standards.

(2) Shop drawings and working drawings

The Contractor shall submit to the PMO/Engineer for his approval the following working drawings:

- Layout drawings of equipment including list of equipment and materials to be incorporated,
- Details of piping and valving,

- Details of sleeves and opening for piping,
- Details of supports, hangers, attachments and anchoring,
- Details of vibration isolation,
- Details of foundation for equipment,
- Detailed layout of electric wiring and conducting,
- Complete electrical connection diagrams and
- Other drawings as required by the PMO/Engineer.

The working drawings shall be submitted at least 60 days prior to starting installation of materials or equipment.

(3) Safety requirements

Belts, pulleys, chains, gears, coupling, 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.

(4) Electrical work

Electric-motor-driven equipment specified herein shall be provided complete with motors, motor starters and controls. Electric equipment and wiring shall be in accordance with Electrical Works hereinafter. Electrical characteristics shall be as indicated. Motor starters shall be provided complete with properly sized thermal overload protection and other appurtenances necessary for the motor control specified. Manual or automatic control and protective or signal devices required for the operation herein specified and any control wiring required for controls and devices, but not shown on the electrical plans, shall be provided.

(5) Basic design data and conditions

(a) Climate data

Mean monthly maximum temperature: 35°(Drybulb)

Mean monthly maximum humidity : 85% (Relative humidity)

(b) Design conditions

Design conditions for the air conditioning system for the building shall be as follows :

Room conditions: 30°C (Drybulb temperature)

(6) Other particulars

The provisions set out in the foregoing Plumbing Works shall be applied here as applicable in its spirit regardless of the wording as listed below:

- Shop drawings and working drawings,
- Data and samples,
- Operation and maintenance manuals,
- Attachments and spare parts,
- Tools,
- Field instructions,
- Tests,
- Floor, wall and ceiling escutcheons, and
- Foundation for equipment.

21902 Air Conditioning System

(1) Airconditioning System

The airconditioning system shall be an energy conservation type controlled by electronic remote controller according to the variations of load in the rooms.

The system shall be of split type consisted of indoor units and single or multiple outdoor units ; the indoor units are cooling units and the outdoor units condensing units.

The indoor units shall be of split type ceiling mounted type unless otherwise directed by the PMO/Engineer, which shall house cooling coils and fan(s).

The outdoor units shall be air-cooled type housing condensor coils, fan(s) and compressor(s), connected with the indoor units with refrigerant piping system.

A room controller shall be provided in each room which shall enable an automatic control of the indoor unit in air floor rates (hi/low), temperature setting, on/off timer, self-diagnosis function etc.

(2) Refrigerant Piping

(a) Cooper tubing

Copper tubing shall be soft annealed where bending is required and hard drawn where no bending is required. Soft annealed copper tubing shall not be used in sizes larger than 35 mm. Joints shall be brazed except that joints

on lines 20 mm and smaller may be flared.

(b) Fittings for copper tubing

Fittings for flare joints shall be standard forged-brass flare type with short-shank flare units. Fitting for brazed joints shall be wrought-copper or forged-brass sweat fittings. Cast sweat-type fittings shall not be allowed for brazed joints.

(c) Pipe insulation

Refrigerant piping line shall not be insulated until after the pipe have been proven tight under the required test pressures. The insulation material shall be fibrous glass, mineral fiber or flexible foamed plastics. The insulation thickness shall be as recommended by the manufacturer of the air-conditioning equipment. Exposed insulated piping in traffic area shall be fitted with a metal jacket to protect insulation.

(3) Drain Lines

Drain lines shall be provided for each indoor unit. Drain lines shall be sloped in the direction of flow with at a rate of 20 mm per meter. Drains when connected to the sanitary sewer system shall be done so indirectly. Cleanouts shall be provided where indicated or required.

(a) Pipe and fittings

All piping shall be standard-weight galvanized steel. Fittings shall be

standard-weight galvanized malleable iron of drainage pattern.

(b) Water seals

Water seals shall be provided in the condensation drain lines. The depth of each seal shall be equal to the total static pressure rating of the unit to which the seal is connected. Water seals shall be constructed of two tees and an appropriate U-bend with the open end of each tee plugged.

21903 Ventilation System

(1) Air moving devices

Fans may be directly connected to the motor shaft or indirectly to the motor by means of a V-belt drive. Where V-belt drives are used, such drives shall be designed for not less than 150 percent of the connected driving capacity, and motor sheaves shall be adjustable to provide not less than 20 percent speed variation. Sheaves shall be selected to drive the fan at such speed as to produce the specified capacity when set at the approximate midpoint of the sheave adjustment. Motors for V-belt drives shall be provided with adjustable rails or bases. Fans shall be provided with personnel screens or guards on both suction and supply ends except where ducts or dampers are connected to the fan. Fans and motors shall be provided with vibration isolation supports or mountings. Each fan shall be selected to produce the specified capacity at outlet velocity not exceeding the recommendations of an applicable code unless otherwise indicated.

(2) Propeller fans and motors

Propeller fans and motors shall be supported on heavy metal frames designed for wall opening mounting. Fan wheels less than 60 cm in diameter shall be directly connected to the motor, and fans 60 cm in diameter or larger shall be connected to the motor by a V-belt drive. Motors shall have totally enclosed enclosures. Motor starters shall be manual type with general-purpose enclosures. Gravity dampers and rainhood shall be provided on the exterior side of wall. Remote manual switch with pilot indicating light shall be provided.

22000 FIRE PROTECTION SYSTEM

22001 General

The fire protection system shall comprise supplying fire extinguishers.

22002 Fire Extinguisher

Fire extinguishers shall be of dry chemical, heavy-duty, portable, 6 kg capacity, CO_2 pressure operated type.

Each fire extinguisher shall be supplied with a free flowing, moisture repellent fire extinguishing chemical powder. The chemical powder shall extinguish fires in paper, wood, rags, gasoline, petroleum products, gas and chemical and electric fires.

22100 MEASUREMENT AND PAYMENT FOR PLUMBING WORKS, AIR CONDITIONING AND VENTILATION AND FIRE PROTECTION SYSTEMS

22101 General

Measurements for payment and payment method hereinafter specified shall be applied for the plumbing, air conditioning and ventilation and fire protection system work items in the Bill of Quantities. All works shall be complete in every respect; furnished, installed, constructed and tested in accordance with the Drawings and the Specifications and as directed by the PMO/Engineer.

All work items shall include costs for incidental works, spare parts and consumables as specified and any other relevant works which are not explicitly mentioned but reasonably inferable. In establishing the unit prices, however, attention shall be paid to the fact that the incidental works herein have been specified taking the representative work items into consideration, therefore some of them may be irrelevant to some work items.

Should any new work items similar in nature to those in the Bill of Quantities arise during the course of construction, unit prices for these shall be made out arithmetically in one of the following manners:

(1) For pipes, valves, steel sheet and the like, extrapolation or interpolation outside or inside the two nearest unit prices shall be employed.

(2) For airconditioners, fans and pumps, extrapolation or interpolation shall be employed if there are more than two similar work items in the same manner as above (1), and if not percentage of increase or decrease in capacities shall be

considered for the new items. In this case, said capacities shall mean cooling capacity (Kcal/hr) air volume (m^3/min or m^3/hr) and delivery volume (1/min or m^3/hr) respectively.

(3) For other items either of the above methods shall be used as applicable.

No price adjustment shall be made for minor changes or deviations from the Drawings or the Specifications which are due to the manufacturer's standard specifications and which are accepted by the PMO/Engineer as such.

No price adjustment shall be made either for upgraded the quality of materials or equipment which has resulted from the industrial advancement in the country of origin during the course of construction period.

22102 Measurement and Payment

Measurement for payment for each work item shall be made on the basis of the following factors, and payment for these shall be made at the unit prices in the Bill of Quantities so established according to the measurements.

	Work Item	Basis of Incidental works Measurement/(Scope of works)
(1)	Galvanized steel pipes:	Length of pipe measured in linear meters./ All fittings, supports, hangers, sleeves and earth works.
(2)	Flexible joint pipes:	Number of flexible joint measured in pieces./

	Work Item	Basis of Incidental works Measurement/(Scope of works)
(3)	Valves and flow meters:	Number of valves and flow meters in pieces./Valve casing and earth works.
(4)	Thermal insulation for pipe:	Length of pipe insulated measured in linear meters./ Vapor varier and jacket.
(5)	Painting for pipe:	Length of pipe painted measured in linear meters./
(6)	Spare parts and consumables:	Total /cost measured in lump sum./
(7)	Cess pool:	Number of cess pool measured in pieces./ Cast iron manhole cover, bottom inverting and earth work.
(8)	Catch basin:	Number of catch basin measured in pieces./ Cast iron manhole cover and earth work.
(9)	PVC drainage pipes:	Length of pipe measured in linear meters./ All fittings, supports, hangers, soldering, sleeves and earth works.
(10)	Septic tanks:	Number of septic tank measured in sets./All accessories specified, and earth works.
(11)	Plumbing fixture	Number of plumbing fixture and shower set measured in set./ All accessories specified, mirrors, shelves, paper holders, soap dispensers, faucets and stops.
(12)	Swing faucets and wall faucets:	Number of faucet measured in pieces./
(13)	Lawn faucets:	Number of lawn faucet measured in sets./ Cast iron faucet boxes and earth works.

Work Item	Basis of Incidental works Measurement/(Scope of works)
(14) Floor drains:	Number of floor drain measured in pieces./
(15) Cleanouts:	Number of cleanout measured in pieces./
(16) Vent caps:	Number of vent cap measured in pieces./
(17) Air conditioner : (outdoor and indoor units)	Number of units measured in unit./ All auxiliary equipment and accessories
(18) Electrical control:	Total cost measured in wiring: l u m p sum./(The works shall include all conduiting and cabling for equipment from the local control panel.)
(19) Copper pipes:	Length of pipe measured in linear meters./ All fittings, supports, hangers, insulation and painting.
(20) Galvanized steel pipe for condensing water (drain) pipes:	Same as (1) Galvanized steel pipes.
(21) Exhaust fans:	Number of fan measured in set./Hangers, supports, rainhood, gravity damper and painting.
(22) Fire extinguishers:	Number of fire extinguishers measured in pieces./All accessories.

22200 ELECTRICAL WORKS

22201 Scope of Work

These Specifications cover all work necessary for designing, detailing, manufacturing,

supplying, testing, finishing, painting, packing for export, insuring, shipping, delivering to the Site, erecting,site testing and cooperating in the commissioning of all lighting and receptacle systems in the building.

22202 Electrical Terminal Point

Electric power for lighting and receptacle systems shall be obtained in each building as follows:

(1) Operation building

A circuit will be provided in one of the switchboards in Electric Room under Chapter 4 Electrical Works, in 4-wire, 400/230 volts. Feeder line from there shall be conducted to the panelboard for lighting and receptacles shown on the Drawing.

(2) Chemical building

Feeder line will be conducted from one of the switchboards in Electric Room of Operation Building under Chapter 4 Electrical Works to the panelboard indicated on the Drawing.

(3) Chlorination building

The same as Chemical building.

(4) Workshop

The same as Chemical building.

22203 General

Materials/equipment shall be new, the best of their respective kinds and such as are usual and suitable for work of like character. All materials/equipment shall comply with the latest issues of the specified standard unless otherwise specified or permitted by the PMO/Engineer.

Workmanship shall be of the highest class throughout to ensure reliable and vibration free operation under all possible operating conditions. The design, dimensions and materials of all parts shall be such that the stresses to which they may be subjected shall not cause distortion, undue wear, or damage under the most severe conditions encountered in service.

(1) Standards

The design, materials, manufacture, testing, inspection and performance shall, unless otherwise specified in these Specifications, conform to the authorized standards of the International Electrotechnical Commission (IEC) or equivalent national standards.

(2) Working Drawings and Catalogues

Working drawings, shop drawings or full size drawings shall be prepared and

submitted by the Contractor to the PMO/Engineer for approval as specified herein without extra cost.

The Contractor shall also submit samples or catalogues of materials/equipment for approval as specified without extra cost. The PMO/Engineer will check and review such samples or catalogues for the assurance of compliance with the design concept and in the Specifications.

(3) Electrical and Mechanical Design

Switchgear shall be designed to mechanically endure short-circuit current without thermal and mechanical failure for one (1) second. All enclosures shall be of dust-proof and vermin-proof.

The enclosures shall be totally enclosed, by sheet steel panels not less than 2.3 mm thick, with angle or channel edge bent, seamwelded at corners, and ground smooth. Outside panels shall not be drilled or welded for attaching wires, resistors, or instruments.

Each enclosure shall be constructed so as to meet the required installation method; self-supporting, wall-recessed or wall-mounted type.

The degree of protection for the enclosures shall be as follows, conforming to IEC 144.

(a)	For indoor installation	IP41
(b)	For outdoor installation	IP54

The enclosures shall be provided with access doors to facilitate inspections of the equipment. The door shall be provided with suitable handles with locks.

Space heaters for 230 V or 400 V A.C. shall be provided inside the enclosure to prevent moisture condensation. A manual switch to control the heaters shall be provided in the enclosure.

(4) Measuring Instruments

All measuring instruments shall be of flush-mounted, back-connected, dust-proof and heavy duty switchboard type. Each measuring instrument shall have a removable cover, either transparent or with a transparent window. Each instrument shall be suitable for operation with the current transformers and voltage transformers under both normal and short-circuit conditions.

Scale plates shall be of a permanent white circular or rectangular finish with black pointer and markings. The scale range shall be determined from the current transformer and voltage transformer ratios.

All measuring instruments shall be approximately 110 mm square enclosures and shall be provided with clearly readable long scale, approximately 240 degrees. The maximum error shall be not more than one and a half (1.5) percent of full scale range.

The wattmeter and watthour meter for the low voltage circuit shall be of 3-element, 3-phase, 4-wire type with a reverse running stop.

(5) Indicating Lamp Assemblies

Indicating lamp assemblies for the enclosures shall be of the switchboard type, insulated for service voltage, with appropriately coloured lamp lenses and integrally mounted resistors for service voltage. The lamp lenses shall be made of a material which will not be softened by the heat from the lamps.

Red indicating lamps shall be used for "ON" position and green lamps for "OFF" position.

(6) Nameplates and Escutcheon Plates

Each cubicle, panel, meter, switch and device shall be provided with a nameplate or escutcheon plate for identification. Each switchgear equipment shall be provided with a rating plate containing the necessary information specified in the relevant IEC standards.

The plates shall be made of weather-proof and corrosion-proof materials and shall not be deformed under the service conditions at site.

The entries on the plates shall be indelibly marked by engraving with black letter on a white background.

The language of all plates shall be English or in accordance with the instruction of the Employer.

(7) Painting

All outside panel surfaces shall be primed, filled where necessary, and given not less than two coats of synthetic undercoat. The finishing coat for the outdoor installations shall be a gloss paint and for the indoor installations shall be a semigloss paint.

The inside surface of the enclosures shall have two prime coats and one finishing coat of light cream colour.

The colour scheme for the finishing coats of all equipment, frames for meters and relays, and switch handle shall be proposed by the Contractor with presentation of colour samples or colour chips and shall be subject to the PMO/Engineer's approval.

The humid and tropical conditions shall be taken into account on selection of the paints and painting procedure.

22204 Wiring

(1) General

All wiring shall be done with PVC insulated wire not less than 2.5 sq.mm except for electronics devices. A suitable wiring duct system shall be installed for all interpanel and front-to-rear panel wiring which will provide easy access for inspection and replacement. As far as possible all wiring shall be installed in wiring ducts.

All wiring from hinged door panels to the fixed panels shall be done with flexible conductor of equivalent size.

Wiring between terminals of the various devices shall be point to point. Splices or tee connection will not be acceptable. Wire runs shall be neatly trunked or clamped.

Exposed wiring shall be kept to minimum, but where used shall be formed into compact groups suitably bound together and properly supported.

Instrument transformer secondary circuits shall be grounded only at the first panel entered, and shall not be grounded at any point of outside of the enclosures.

Cable supports and clamp type terminal lugs shall be provided for all incoming power wiring terminated at each panel. All wires shall be marked near each terminal end with circuit or wire designation. These markers shall be of an approved type and permanently attached to the conductor insulation.

(2) Phase arrangement

The standard phase arrangement when facing the front of the panel shall be R-S-T-N, and R-N-S from left to right, from top to bottom, and front to back for A.C. three-phase and single-phase circuits and N-P from left to right, P-N from top to bottom and front to back for D.C. polarity. All relays, instruments, other devices, buses and equipment involving three-phase circuit shall be arranged and connected in accordance with the standard phase arrangement where possible.

(3) Wiring color code

All wires shall be colored as follows:

Circuit	Color
Voltage transformers	Red
Current transformers	Black
A.C. circuit	Yellow
D.C. circuit	Blue
Grounding circuit	Green with yellow stripes

(4) Phase and polarity color code

Following colored ferrules shall be provided on each wire in order to identify phase and polarity.

Phase and Polarity		Color
A.C.,three-phase,	first phase	Red
	second phase	Yellow
	third phase	Black
A.C.,single-phase,	first line	Red
	second line	Yellow
Neutral		Black

Grounding		Green with yellow stripes
D.C.,	positive	Red
	negative	Blue

22205 Terminal Blocks

Terminal blocks for control wiring shall be rated at not less than 600-volt with cover and be of the molded type with barriers.

White or other light-coloured marking strips, fastened by screws to the molded sections at each block, shall be provided for circuit designation.

Each connected terminal of each block shall have the circuit designation placed on the marking strip with permanent marking fluid. The terminal arrangement, including the terminal blocks for PT and CT circuit connections, shall be subject to the PMO/Engineer's approval. Spare marking strips shall be furnished with each block.

At least 10 percent spare terminals shall be provided for each terminal block group.

22206 Tests

The tests to be carried out before shipment at the manufacturer's plant and at Site shall be as stated in the relevant Clause.

22207 Lighting and Receptacle Systems

(1) Scope of work

The following lighting and receptacle systems shall be supplied and installed as shown on the drawings.

(a) Indoor lighting and receptacle systems
(b) Single or three phase motor power system for some of the building service equipment installed in the buildings.

The following apparatuses and materials shall be furnished and installed to complete the lighting and receptacle systems.

(i) Panelboards
(ii) All conduits and electrical cables and wires for the panelboards, lighting fixtures, receptacles, etc.
(iii) Lighting fixtures including bulbs and support
(iv) Conduit piping and wiring works
(v) Miscellaneous materials to complete the systems.

(2) Electrical Apparatuses and Materials

(a) Panelboards

(i) Construction requirement

The panelboards panels shall be of wall-recessed type for indoor

installations and of wall-mounted type for outdoor installations and shall generally be constructed in as specified hereinbefore.

A copper ground busbar with ample size shall be provided in the panel. Clamp type grounding terminals shall be provided for grounding system.

Electric circuits, classification, rating and numbers of molded case circuit breakers, electromagnetic contractors, switches, etc. for the panels shall conform to the Drawings. A card holder with a card for each circuit designation shall be provided with the back of each panel's door plate.

(ii) Molded case circuit breakers

The molded case circuit breakers for the panels shall be one- or three-pole for A.C. circuits and two-pole for D.C. circuit, manual operated, fixed type with time-delay overcurrent tripping and magnetic instantaneous short-circuit current tripping mechanism, and with residual current tripping mechanism as required.

The molded case circuit breakers shall be rated as follows:

For A.C. circuits

i)	Rated insulation voltage	600 V
ii)	Rated operational voltage	
	– for three–pole	400 V
	– for one–pole	230 V
iii)	Rated short–circuit breaking current	2.5 kA
iv)	Rated residual current (if required)	30 mA

For D.C. circuits

i)	Rated insulation voltage	250 V D.C.
ii)	Rated operational voltage	110 V D.C.
iii)	Rated short–circuit breaking current	2.5 kA

The rated frame currents and the rated trip currents shall be determined by the Contractor to suit the rated short–circuit breaking current and the overcurrent protection and shall be subject to the PMO/Engineer's approval.

(iii) Accessories

The following items shall be provided for the panelboards:

i) Nameplate for each panel
ii) Foundation bolts and nuts
iii) Grounding pads
iv) Other necessary accessories

(b) Lighting fixtures

The lighting fixtures shall be complete with ballasts and lamps. Fluorescent lighting fixtures shall be equipped with complete fittings for A.C. 230 volts, 50 Hz source, and ballasts of high power factor.

Mercury lighting fixtures shall be equipped with a screwed base lamp holder suitable for high-pressure mercury lamp, and appropriate ballast of high-power factor for stable operation.

The lighting fixtures for outdoor lighting shall be of rain-proof type. The lighting fixtures to be installed in wet and damp places shall be of moisture proof.

(c) Insulated wires and power cables

The sizes of insulated wires and power cables shall conform to the Drawings.

Insulated wires to be used for indoor wiring shall be of 600 V grade, PVC insulated single-core tinned copper wire.

Power cables to be used for connection between the terminal point and the panelboards shall be of 0.6/1.0 kV crosslinked polyethylene (XLPE) insulated, PVC sheathed cable.

(d) Joint boxes

The boxes for wire joints to be concealed in concrete shall be of galvanized sheet steel type and shall be fitted with appropriate covers, where necessary, to set the boxes flush with the finished surface of the structure. The boxes to be used for the exposed installation shall be of galvanized cast steel or alloy to be fitted with appropriate fittings and covers.

(e) Tumbler switches

Wall switches shall be of fully enclosed, recessed or surface mounting, tumbler type, rated at 300 volts, 15 amperes.

(f) Receptacles

Receptacles shall be of 3-pin type rated at 250 V, 15 A available in Mauritius, and shall be of wall-recessed or surface-mounted type with appropriate cover.

Receptacles to be installed in wet and damp places shall be of moisture-proof type.

Unless otherwise noted on the Drawings, the mounting height of the outlet shall be 300 mm above floor to the center of the box.

(g) Conduits

The rigid steel conduits of thick wall galvanized type shall be used for

cabling and wiring. The conduits shall have a minimum thickness of 2.3 mm and have a minimum inside diameter of 16 mm. Where the conduits are installed in expose, they shall be coated with epoxy enamel of which color shall be directed by the PMO/Engineer.

(h) Miscellaneous materials

All apparatus,accessories and materials, which have not been specifically mentioned but which are necessary for the efficient performance of the works, shall be provided by the Contractor.

(i) Motor control panels

The motor control panels shall be provided for power distribution and automatic control of the air conditioning and ventilation equipment etc. as required.

Each motor control panel shall be composed of the enclosure, busbars and withdrawable type motor starter units with molded case circuit breakers, eletromagnetic contactors, relays, timers, terminal blocks, wirings and other devices necessary for the required controls. The control circuit voltage shall preferably be 230 V A.C. of single-phase. The required step-down transformers with adequate rating shall be contained in the motor control panel.

Indicating lamps for operating status and for fault annunciation shall be mounted on the front panel of the enclosure.

(i) Construction requirement

The motor-starter unit shall be housed in the indoor installation, floor-starting or wall-mounted type metal enclosure and shall be withdrawable from the front panel.

(ii) Molded case circuit breaker

The molded case circuit breakers for the motor control panel shall be of three-or two-pole, manual operated type with rotary operating handle located on the starter unit panel front. It shall be possible to lock the circuit breaker in ON and OFF positions by means of padlock.

The molded case circuit breaker shall be provided with thermal time-delay overcurrent tripping and magnetic instantaneous short-circuit current tripping mechanism.

(3) Installation

(a) General

All installation works shall be carried out by the Contractor in accordance with the applicable standard, these Specifications and the instruction of the PMO/Engineer. The arrangement of fixtures and apparatus shall conform to the Drawings. The Contractor shall submit working drawings for approval indicating routes and sizes of electrical wires and conduits.

(b) Lighting fixtures

The exact location and height of the lighting fixtures shall be determined by the Contractor from the structural and mechanical limitations of the building. The lighting fixtures shall be installed in such a manner as to avoid obstructions and to give the proper illumination results, and shall not injure outlet boxes, conduits, walls, ceiling, etc. by their weights. Lamps shall be in the position at the completion of construction work.

(c) Conduit work

Conduit shall be concealed within or pierced through the structure without effect on their construction and strength. The cut ends of conduit shall be smoothed.

Pullboxes shall be provided for the conduit system to give an easy leading in or replacement of the wires. The bending radius of conduit shall be not less than 6 times its inside diameter in case normal bend is not used.

Conduits to be buried in the ground shall have a factory-applied plastic resin, epoxy, or coal-tar coating system. The coverage over underground conduit shall not be less than 600 mm below the ground surface.

Exposed runs of conduit shall have saddles or sheet steel supports spaced not more than 1.5 meters and also shall be supported at least at 2 positions. They shall be installed to run in parallel with or perpendicular to walls, structural members, or intersections of vertical planes and ceilings, with right-angle turns.

Outlet boxes or switch boxes with appropriate covers shall be provided at the places where the lighting fixtures, receptacles and tumbler switches are installed.

Conduit shall be installed in such a manner as not to allow condensation trapped in the conduit. U-shaped piping shall be avoided as far as possible. Conduits shall be connected with each other by means of screwed or non-screwed coupling and also shall be securely fastened to all sheet-metal outlet, junction and pull boxes with galvanized lock-nuts and bushings. Conduits in exposed work shall be screwed with boxes and other fittings. Connected portion of conduit system shall be coated with anti-corrosive paint. Exposed runs of conduit including boxes, supports and all other fittings shall be painted, of which color will be instructed by the PMO/Engineer.

The Contractor shall carry out the necessary precautions to prevent the lodgement of dirt, plaster, trash or damp in conduits, fittings, and boxes during the course of installation. A run of conduit which has become clogged shall be entirely freed of these accumulations or shall be replaced.

(d) *Indoor cable laying*

Cables shall be securely fastened along the structure with saddles or other suitable supports spaced not more than 1.5 meters apart, but not more than 1 meter apart where it is likely to come in contact with persons. Metallic racks and the like shall be installed in cable ducts and shafts for laying, where necessary. Conduits shall be utilized where the cables may be injured. Cables shall be laid in conduit where they are concealed in the

concrete structure to protect the cables and to give an easy replacement thereof. In this case, the bore of conduits shall be not less than 1.5 times of outside diameter of cables. The bending radius of cable shall be not less than 6 times their outside diameter. The cables, when drawn into conduit, shall not be bent at more than 2 portions and these bending angles shall not exceed 180 degrees in total. Cable splicing shall be completely made by means of sleeve joining, lapped with insulating tape, without increase of electrical resistance, deterioration of insulation strength and decrease of tensile strength. No splices shall be made except within panelboards, outlet boxes and junction boxes.

Wires shall be continuous from outlet to outlet and no splices shall be made except within outlet, junction boxes or panelboards. No oil or grease shall be used for wiring as a lubricant. The interior of conduit system shall be fully cleaned up before wiring.

(e) Cable laying in trench

The cables to be installed in the floor trenches where shown on the drawings shall be laid on the bottom of the trench or fastened to the wall of trench in neat workmanship. Each cable shall be provided with tag to indicate circuit number or circuit designation. The cables to be fastened to the trench wall shall be supported with factory made devices at 1,500 mm intervals.

(f) Grounding

Unless otherwise directed by the PMO/Engineer, all non-current carrying

metal parts of electrical equipment and fixtures shall be grounded through rigid steel conduit system. All joints of conduits shall be tight. The conduits shall be connected with the grounding system as far as applicable. Green colored PVC insulated wires shall be used for grounding purpose.

(g) Pull boxes

Pull boxes shall be installed approximately where shown on the Drawings. The exact locations of pull boxes shall be determined by the Contractor and shall be subject to the PMO/Engineer's approval. The pull boxes shall be of metal sheet galvanized type, the size of which shall be 150 mm x 150 mm x 100 mm.

(h) Other apparatuses

Switches, receptacles and other apparatuses shall be installed according to the Drawings. All apparatuses shall be securely screwed and fastened.

(4) Tests

(a) At the manufacturer's works

The tests required by the applicable standards shall be carried out by the Contractor before shipment at the manufacturer's shop and the test reports shall be submitted to the PMO/Engineer for his approval.

(b) At the Site

The following tests shall be carried out by the Contractor at the Site after the completion of installation.

a) Operation test
b) Measurement of insulation resistance (2 M-ohm or more)
c) Circuit continuity test

22208 Measurement and Payment

Measurement for payment for the supply and installation of the lighting and receptacle systems shall be made on the actual installed number or length as follows :

(a)	Panelboards :	measured in sets
(b)	Lighting fixtures:	measured in sets
(c)	Insulated wires and cables:	measured in meters
(d)	Joint boxes:	measured in pieces
(e)	Tumbler switches:	measured in pieces
(f)	Receptacles:	measured in pieces
(g)	Conduits:	measured in meters
(h)	Handhole:	measured in pieces

Payment shall be made of the length or numbers measured as provided above at the unit prices stated in the Bill of Quantities which unit prices shall constitute full compensation for the cost of all labors, tools, apparatuses, equipment and materials including those for the tests, excavation, backfill and other items necessary to complete the work.

22300 LABORATORY EQUIPMENT

The Contractor shall furnish all the laboratory equipment including glassware specified hereinafter.

All laboratory equipment specified hereinafter shall be shop fabricated. All the equipment which require electric supply shall be wired and tested. Power source for the laboratory equipment shall be 230 V, single phase, 50 Hz. Catalogues of laboratory equipment shall be submitted to the PMO/Engineer for his approval.

For each equipment, all essential and desirable accessories for an installation and operation shall be furnished.

The Contractor shall prepare all materials and equipment for shipment in such a manner to protect laboratory equipment including glassware, chemicals and others from damage in transit, and during a prolonged storage period in hot, humid climate.

If any defects in the fabrication of equipment and damaged glassware are found out under field checking and testing, the Contractor shall be required to replace them with new ones at his own expense. Any repairing for equipment shall not be permitted.

Schedules of equipment including glassware are as follows:

1. Turbidimeter

Type	:	Ratio Turbidimeter
Number	:	One (1) unit
Method of Detection	:	Nephelometric signal rationed against sum of forward scattered light and transmitted light signals.

Range	:	0 – 5, 0 – 50, 0 – 500, 0 – 2000 NTU
Resolution	:	less than 0.01 NTU on 0 – 5 NTU range
Sample cells	:	each less than 25 ml for various ranges of turbidity, 2 (two) spare cells shall be provided.
Standard solutions	:	A series of standard solutions prepared in similar schedule as 1.0 NTU, 10 NTU, 100 NTU, 1000 NTU shall be provided.

2. pH meter

Type	:	Compact laboratory pH meter with display unit and electrode and stand.
Number	:	One (1) unit
Measuring range	:	0 to 14 pH
Resolution	:	0.01 pH
Display	:	Digital 3 1/2 digit LCD
Temperature compensation	:	Automatic

3. Conductivity meter

Type	:	Compact conductivity meter with display unit and cell holder and cell stand
Number	:	One (1) unit
Measuring range	:	At least 0 to 2,000 micro S/cm with adjustable range of: 0–50, 0–100, 0–500, 0–2,000 micro S/cm
Resolution	:	less than 0.1 micro S/cm
Temperature compensation	:	0 to 50 degrees C (Manual and Auto Changeover)

4. Laboratory flocculator (Jar tester)

Type	:	Jar tester with 6 variable speed paddles, paddles control and timer
Number	:	Two (2) unit
Adjustable speed range	:	0 to 160 rpm

5. Laboratory balance

Type	:	Digital display analytical balance
Number	:	One (1) unit
Max. weighing capacity	:	At least 200 g
Min. division	:	Not greater than 1 mg

6. Disc-type comparator

Type	:	Lovibond 2000 or equivalent complete with sample cells, discs, and chemicals for chlorine, colour and ammonia
Number	:	One (1) set
Chemicals	:	Chemicals necessary for the measurement of free chlorine, total chlorine, and ammonia shall be provided for 500 samples each.
Discs for chlorine	:	permanent colour standards in the chlorine range from 0.0 - 1.0 mg/l, 0.0 to 2.0 mg/l.
Discs for ammonia	:	0.0 - 1.0, 0.0 - 2.0 mg/l
Discs for colour	:	0 - 70 Hazen unit
Sample cell	:	five (5) sample cells each for chlorine, colour and ammonia

7. DO meter (Dissolved Oxygen meter)

Type	:	Digital display portable type
Number	:	One (1) set
Measuring item	:	DO, O2, Temperature
Measuring range	:	DO: 0 - 20 mg/l, Temp.: 0 - 40 °C O2: 0 - 25 %
Resolution	:	D0: 0.1 mg/l, O2: 0.1%, Temp: O.1 °C
Accuracy	:	DO: ±0.1 mg/l, O2: ±0.1%, Temp: ±0.2 °C
Response	:	less than 15 sec for 90%
Extension cable for sensor	:	60 m

8. Water Sampler

Sample volume	:	500 ml
Type	:	Generally used for sampling of deep water in reservoirs, and suite to sample water more than 60 m deep. Kitahara type or equivalent
Number	:	One (1)

9. Glassware and miscellaneous

	Item	Quantity
(1)	Beaker 1,000 ml (Borosillicate hard flask) for Jar-test	6 Nos.
(2)	Beaker 500 ml plain (– do –)	6 Nos.
(3)	Beaker 50 ml	4 Nos.
(4)	Graduated glass measuring cylinder	
	250 ml	2 Nos.
	500 ml	2 Nos.
	1,000 ml	2 Nos.
(5)	Conical flask 250 ml	6 Nos.
(6)	Whatman's No.1 filter paper, 185 mm (box of 100)	10 Nos.
(7)	Specimen jar cylindrical ground with glass stopper 500 cc capacity for Alum and Lime solution (Jar-tests)	4 Nos.
(8)	Measuring Pipette graduated	
	0.1 to 1.0 ml	6 Nos.
	1.0 to 5.0 ml	6 Nos.

(9)	25 ml pipette with one mark to precise quantity	4 Nos.
(10)	Glass stirring rods min. 20 cm long	4 Nos.
(11)	Automatic Buret 1 litre	3 Nos.
(12)	Distilled water 20 litres container	1 No.
(13)	Fish breeding tank,stainless steel frame, glass water tank with 20 mm dia. overflow pipe and clear plastic baffle plate, size of 400 x 900 x 500 mm high	1 No.