302. MATERIALS

302.1 APPLICABILITY

All materials incorporated in the works shall be the most suitable for the duty concerned and shall be new and of first class commercial quality, free from imperfection, and selected for long life and minimum maintenance.

302.1.1 Materials in Contact with Potable Water

Any non-metallic materials such as may be employed for bellows, packing or sleeves, coatings or linings etc. liable to come in contact with potable water shall be approved for the purpose by a recognised approval body.

302.1.2 Materials in Contact with Sewage

Materials in contact with sewage shall be suitable for the environment but particularly all bronze materials shall be true bronze (i.e. zinc free) alloys.

302.2 WROUGHT STEELS

Where not otherwise specified wrought steel shall be selected from the appropriate EN series of BS.970 and be free from blemishes, shot or hammer marks.

The Contractor shall submit for the approval of the Engineer, the EN number selected for the various components.

302.3 CAST MOLYBDENUM STEEL

Cast molybdenum steel shall be supplied to BS 3100.

302.4 CAST IRON

All grey iron castings supplied shall be to the appropriate grade in BS 1452.

All castings are to be free from blowholes, flaws and cracks.

The Contractor shall replace any casting which the Engineer considers is not of first class appearance or in any way is not the best which can be produced, although such a casting may have passed the necessary hydraulic test or other tests. No plugging, filling, welding or "burning on" will be acceptable.

302.5 BRONZE

Where not otherwise specified the bronze used shall be made of a strong and durable mixture of 88:10:2.

302.6 ALUMINIUM AND ALUMINIUM ALLOYS

Castings shall be manufactured from LM5 to BS 1490 and bars and sections from BS 5083 to BS 1490 and bars and sections from BS 5083 to BS 1474 or similar.

Full details of the composition of each alloy shall be supplied to the Engineer for approval, before commencing manufacture.

Immersed structures or structures that are periodically immersed shall not be constructed from aluminium or aluminium alloys.

303. EQUIPMENT

303.1 FLEXIBLE COUPLINGS

Flexible couplings where supplied, shall be generously rated to cover the full range of duty.

Couplings liable to impregnation by oil shall be of the all metal flexible type.

General service couplings shall be of the flexible multi-pin and bush type, having not less than six bushes and each bush shall have an inner sleeve to allow rotation on the pin (bushes shall not be in direct contact with the pin). All pins shall have shoulders to allow positive location and securing to the bosses.

Bosses shall be a tight fit on the shafts and secured with hand fitted keys.

Couplings shall be supplied in matching balanced sets and shall be machined, balanced and marked before leaving manufacturer's works.

303.2 STRAINERS

Strainers shall be flange mounted type. Foot strainers shall be installed at least 0.5 m above the bottom of the water reservoirs.

The strainer basket shall be of the perforated cylinder type made from galvanized steel or stainless steel. It shall be easily accesible via a removable flange.

303.3 GEARBOXES GENERAL REQUIREMENTS

The gearboxes shall be totally enclosed, robustly constructed and suitable for continuous and arduous duty. They shall incorporate ball and/or roller bearings. Taper roller bearings shall be incorporated in the gearbox when thrust loads are to be sustained.

Longlife seals on the input and output shafts shall be fitted up to prevent the escape of lubricant and the ingress of dust, sand and moisture. Breather holes and/or pipes shall be sealed to prevent ingress of lubrican contaminants.

Oil level sight glasses fully protected, shall be provided with levels marked for running and filling, minimum and maximum positions respectively. These shall be arranged for easy viewing. Oil filled caps and oil drain plugs shall be provided.

The design ambient ranges shall be 0° - 50° C.

Lubrication of bearings, etc. shall be by either splash or forced feed system.

The Contractor shall ensure that the lubricant used for the initial filling and specified in the maintenance manual is adequate for prolonged operation in ambient temperatures of up to 55°C without overheating.

Cooling may be by convection from the gearbox casings but without assistance from cooling fins or fans. Adequate other cooling means shall be provided as applicable. The exterior of the gearbox shall be free from dust or moisture traps.

Access for inspection purposes shall be allowed for in the design of the gearbox casing.

Substantial eye bolts shall be provided for all reasonable lifting purposes.

The gearboxes shall carry the manufacturer's identification details together with the rated shaft speeds, output power and maximum ambient temperature.

The gearboxes shall conform to the relevant British Standards with respect to the following requirements :

i) The design ambient shall be 0°C to 50°C.

ii) The noise at 120% of the full output power and 50°C ambient shall not exceed 90 dBA at 1 meter.

iii) The gearing shall give double the life of the bearings if subjected to similar loading.

303.4 SURGE SUPPRESSION EQUIPMENT

Surge suppression equipment may be of one of the following systems:

i) A Hydro-Pneumatic system
ii) A Hydro-Nitrogen system
iii) A Surge Anticipation valve system.

303.4.1 Surge Pressure Vessels

Surge pressure vessels shall be designed and constructed to BS 5500, construction category 1, 2 or 3, post weld heat treated and with a corrosion allowance of 1mm. The vessel shall be cylindrical, carbon steel, fusion welded with domed ends and mounted vertically on steel supports. The vessel shall be provided complete including the following fittings:

– McNeil type access manhole with opening not less than 450 mm x 410 mm;
– Water inlet/outlet branch flanged to BS 4504 Table 16 or 25 as necessary;
– 100 mm dia. drain branch with gunmetal valve and handwheel with drain pipework discharging to drainage channel;
– Spring loaded gunmetal safety valve;
– 100 mm dia. glycerine filled pressure gauge complete with gunmetal isolating cock;
– Air/Nitrogen inlet fitting incorporating a release valve, isolating and non-return valves;
– Access ladder;
– Lifting lugs;
– Nameplate giving vessel details.

The pressure vessel may be constructed with or without a bladder of suitable material and shall withstand the maximum test pressure of the system.

The Hydro-Nitrogen pressure vessel shall be connected to and supplied with a Nitrogen bottle(s) and necessary accessories. The Nitrogen bottle(s) shall be of sufficient volume capable of pressurising the vessel to the working pressure.

303.4.2 Magnetic Level Indicator

The sight glass level indicator shall have the following characteristics:

Temperature operating range: -40°C - 400 °C.
Operating pressure range: Vacuum - Max test pressure.
No requirement for energy source.
Pressure compensated floats to avoid float drowning.
Magnetic coupling of the indicator elements.
An excellent readability ensured by resistance against product contamination and UV rays.
Corrosion resistant.
Highest operational safety through separation of liquid & indicator display.
No re-calibration required.
High mechanical strength.

The level indicator shall be equipped with magnetic switches and a continuous control elements and transmitter allowing remote monitoring of water level alarms and controls.

303.4.3 Air Compressors

The air compressor shall be capable of charging the pressure vessel from full of water in approximately 30 minutes. The compressors shall be air cooled, electrically driven and complete with baseplates.

The compressors are required to deliver completely oil-free air but may be of the air lubricated type with two stage carbon air delivery filters providing complete removal of moisture and oil vapour. Each compressor shall be provided with the following features:

- Outlet pressure gauge.
- Pressure relief valve on each stage of compression.
- Suction filter with high separation capacity and silencer.
- Automatic unloading valve for a no-load start under all conditions
- Non-return valve.
- Protective guard between motor and compressor.
- Oil separator filter (Residual oil content 0.05 ppm).
- Filter and dryer for holding back solid and liquid particles of 5 microns.
- Airtight and automatic drainage system with: pneumatic slides, adjustable frequency and duration and controlled by a remote PLC.

303.4.4 Electric Control Panels

Control equipment to provide fully automatic control of the selected duty compressor from the water level measuring instrument of the surge vessel. A time delay shall be incorporated to prevent operation of the compressor during water level changes under surge conditions and a push button feature shall be provided for manual test of the system. The front side shall have a full width door hinged with a rotating handle and positive closing action. The control panel shall include:

- One lock with a key
- Meters with selector switches, HOURMETER/VOLTMETER/ANMETER.
- One switch START/STOP.
- Status indication ON/OFF/FAULT
- Contractors - (Starter).
- One differential thermal protection.
- Control circuit protection circuit breakers.
- One connection terminal (control and power).
- One PLC.
- The required relays for transmitting safety and system regulating data.
- A three pole isolating switch, with operating handle interlocked with the enclosure door.
- A water level control module.
- A non-latching motor test push-button.
- One selection switch LOCAL/REMOTE/ZERO

303.4.5 Pipework

The pipework shall consist of:

Connection between the ductile iron flanged inlet/outlet of the surge vessel and a flanged tee on the pumping station or wellhead delivery pipework.

Compressed air connection pipe shall be seamless galvanised steel for working pressures greater than 35 bars and copper or galvanised steel for working pressures less than 35 bars. Connection pipes to pressure gauge and air compressor shall have a diameter of 12.5 mm (1/2”). The pipework shall be suitably coated and wrapped.

The pipework shall also include an isolating valve, a pierced swing check valve and all necessary bends and fittings required for the complete installation.

303.4.6 Cabling

Between the switchboard and the control panel
Between the control panel and the compressors
Between the control panel and the level electrodes on the surge vessel
Earthing of all equipment.

303.4.7 Surge Anticipation Valves

The valve shall be installed in a by-pass line immediately downstream of the pump(s) and the check valve. The surge anticipation valve shall be interlocked to the pump(s) via the control valve that shall be supplied with the valve.

The basic valve shall be a single-seated, line-pressure-operated, diaphragm - actuated, pilot controlled globe or angle valve. The valve shall seal by means of a corrosion - resistant seal and resilient, rectangular seat disc. These and other parts shall be replaceable in the field; all such service and adjustments to be possible without removing the valve from the line.

The stem of the basic valve shall be guided top and bottom by integral bushings. The basic valve and its pilot control system shall contain no packing glands nor stuffing boxes.

The diaphragm shall not be used as a seating surface nor shall pistons be used as an operating medium. All internal and external ferrous surfaces shall be coated with a high quality, two-part epoxy primer; the exterior to receive a coat of backed enamel paint.

The pilot control system of the valve shall consist of a controlled pilot-valve, an accumulator, a three-way diaphragm actuated pilot valve, an adjustable needle valve for opening speed control, an adjustable needle valve for closing speed control and a "Y" strainer. To isolate the control system from the main valve, inlet and outlet ball stop valves shall be provided.

– Temperature ratings: 0 ^{o}C - 85 ^{o}C

Maximum pressure differential across the diaphragm of the basic valve must not exceed 20 bars.

Valve materials [Pressure Ratings] : Cast iron - ASTM A126/B [< 25 bars]
Forged or Cast steel - ASTM A126/WCB [> 25 bars]
Cast bronze - ASTM B61, B62 [16 - 35 bars]
Cast aluminium 356 - T6 [< 20 bars]
or equivalent International Standards.

– Stem: Stainless steel/Ductile iron

– Seat Ring: Cast bronze or stainless steel

– Electrical Power:
AC, 50HZ, in 110/220 volts.
DC 6, 12, 24, 120, 240 volts.

303.5 LIFTING & HANDLING EQUIPMENT

303.5.1 General

Cranes and hoists shall be of standard proven design in accordance with BS 466, rated for lifting the specified working loads, utilisation and service conditions and shall be suitable for operation from the runway beams provided. Motions shall be motorised as specified with dual speed hoisting facility and controlled from a pendant push button unit via a crane control panel mounted on the gantry.

All operations, wether manual or electric, shall be controlled or performed from motor room floor level unless otherwise specified.

The lifting assembly shall be rated for the highest lift that could occur during installation and maintenance operations, including allowance for stiction.

The crane shall consist of a gantry or jib, crab and hoist assembly, ropes, block and hook together with the necessary running rails and all electrical supply requirements.

Chains used for lifting or travel shall be alloy steel and corrosion protected by an electro-deposited, zinc coated finish after manufacture. They shall not be hot-dip galvanised.

The load chain anchorage, associated fittings and framework at the slack end shall be at least equal in strength to 2.5 times the maximum tension in the load chain when the working load limit is being lifted. Any links used for connecting the load chain to a terminal fitting shall be the material specified for the chain and heat treated to provide mechanical properties and strength equivalent to those of the load chain. the hook shall be made from high grade forged steel complying with BS 2903 "C" type, and provided with a safety catch. The safe working load shall be marked.

Jibs or gantries shall be of plate or box girder design and securely attached to end mountings or carriages.

A reliable braking and locking arrangement shall be incorporated and a load chain collection box shall be incorporated with the crab.

303.5.2 Cross Travel and Long Travel

End carriages for gantries shall be fabricated from rolled steel plates and have two, double-flanged, cast steel wheels to match the track rails. Where rails are supplied and installed under this contract, they shall be adequately supported throughout their length to carry all the dynamic and static loads imposed by the crane duty.

Crab assemblies shall be mounted on four flanged cast steel wheels to suit the jib runway beam or cross-travel rails fixed to the main crane gantry.

Each travel range shall be the maximum permitted by the building and runway constraints. Where applicable the extent of each travel motion shall be limited by electrical limit switches with mechanical end stops secured to the travel rails beyond the electrical limit switch positions, to prevent overrun and building damage from swinging loads mechanical end stops shall also be provided where travel is by manual operation.

In the case of electric motor driven travel two travel speeds shall be provided. The fast speed shall not exceed 16m/min and the slow speed not exceed 4m/min. These drives shall always start at the lower speed and incorporate smooth acceleration and deceleration controls.

303.5.3 Hoist

The hoist unit on travelling beams shall be mounted to provide the highest possible lifting facility whilst maintaining adequate clearance between the crab/hoist assembly and the building structure and fittings.

Hoist units fitted to single runway beams, fixed or jib mounted, shall be of the self-suspension type mounted on a single rigid trolley suitable for manual geared travel along the runway beam. Two end stops shall be provided on the beam suitable for the trolley provided. The trolley shall have ball or roller bearings grease packed for life.

The hook shall be fitted with a swivel and a safety catch and be capable of touching the floor and providing a minimum lifting height as specified.

In the case of electrically operated hoists the normal hoist speed shall be approximately 4 metres/min and the creep speed shall be approximately 600mm/min or nearest standards. An overload device and overwind limit shall be included to prevent dangerous overloads. Raise and lower limit switches shall be provided at the maximum and minimum lift positions. Instantaneous fail safe braking in the event of power failure shall be provided.

Where operation is by electric motor a power supply shall be provided under the contract. Power shall be taken from a feed in the main distribution panel forming part of the works and a wall mounted fused isolator shall be provided at a suitable location approximately 1.5 m above floor level alongside the lifting installation.
Power transmission to the moving installation shell be by pick up shoe running along the underside of shrouded rails, suspended concertina cable running on slides or a rail or a cable from a self winding cable reeling drum . In the latter case the tension in the cable shell be controlled and supports provided to prevent the cable drooping more than one metre below the crame rail (s).

303.5.4 Rating Plates

The SWL shall be clearly marked in Arabic and English language on the rating plate and shall be legible from the plant working level.

303.5.5 Paint Finish

The finish colour shall be a full gloss Yellow Colour No. 356 to BS381C or equivalent reference 08 E 51 to BS 4800.

303.5.6 Crane Access

Where clearances permit, provision for safe access for maintenance shall be provided in accordance with BS 466 and shall include a walkway across the span having a height clearance of 2m and be fitted with double-tiered handrails and toe boards.

An extending, portable aluminium ladder shall be provided for access to the crane for maintenance etc.

303.5.7 Crane Controls

The electrical controls shall be designed to prevent excessive acceleration, retardation, skidding and load swinging and all motions of the crane shall be arranged to be switched through the slower speed where provided.

The control circuits for the crane/hoist shall operate at not more than 110V and be derived from a double wound, screen earthed isolating transformer with one side of the secondary winding connected to neutral/earth. The primary supply shall normally be from the phase conductors.

Fuses shall be provided on each primary and secondary supply and be clearly labelled and segregated. A link shall be fitted in the neutral/earth connection.

303.5.8 Control Panels

The crane control panels shall be constructed of sheet steel or other approved material and shall be hoseproof (IP65).

The control panel shall be mounted on the traveling crane hoist bogie in a convenient position for inspection and maintenance, and shall house all the fuses, motor protection devices, starters and control equipment for controlling the crane/hoist. All contactors shall be of the air-break, electrically operated hold-on type with all necessary auxiliary contacts. Reversing contactors shall be mechanically and electrically interlocked to prevent conflicting operations.

The panel shall be fitted with a main isolating switch interlocked with the door to allow access only when the switch is open.

The motor starters shall be provided with adjustable overload protection devices suitable for the motor load at each speed and having manual resetting facilities within the panel.

All control equipment shall be fitted with suitably rated fuses. Fuse ratings shall be rationalised as far as possible to limit spares. Where practicable, fuses shall be housed in all-insulated carriers with fully shrouded bases.

Fuse links shall be HRC cartridge type to BS 88, Class Q1, having provision for screw fixings for attachment to the carrier.

303.5.9 Pendant Controls

A heavy duty, industrial pattern pendant push-button control station shall be provided, having sets of non-maintained push-buttons for each hoist speed and function specified.

Each set of buttons shall be electrically and mechanically interlocked so that conflicting operations are prevented and only one function can be initiated at one time.

The push-button enclosure shall be of a tough neoprene rubber suitable for withstanding arduous duty and provide full electrical safety, each button being suitably labelled with its function. It shall have an IP55.

The pendant shall be divorced from the crab and capable of independent cross travel. It shall be suitable for vertical adjustment for operation from alternative levels by means of spring loaded

reeling drum fitted with a ratchet device or motor driven reeling drum and have a cable guide runner to assist re-coiling.

Pendant control cables shall be designed for reeling drum application and have stranded copper flexible conductors, EPR insulated to 300/500V, multicores laid-up with an internal central textile strain carrier and heavy duty, textile braid reinforced, PCP sheath.

For non-reeling applications, the outer sheath may be flexible PVC, incorporating externally laid, galvanised steel, nylon coated strainer wires.

303.5.10 Radio Control

Where specified, the crane remote control shall be by means of radio transmitter and receiver units operating within the UHF waveband range approved by the relevant authority. The receiver shall be accommodated on the crane in a metal enclosure to IP55, having shock absorbing, rubber mountings, an external receiving aerial and incorporate an output relay for each transmitter function.

The transmitter shall be a lightweight, hand held device enclosed in a heavy duty impact resistant enclosure to IP67 complete with a bandoleer carrying strap.

The unit shall be powered by rechargeable batteries having capacity for 10 hours continuous operation on fully charged batteries. To conserve battery life, a 'time out when not in use' function shall be incorporated and the stop button shall be fitted with a key switch to prevent unauthorised use. All push buttons shall be spring returned to the 'off' position and interlocked to prevent conflicting operations. Programmable security coding shall prevent operation from unwanted signal interference.

A suitable wall mounted, metal enclosed charger shall be provided to enable the transmitter to be connected and maintained in a fully charged condition when not in use.

303.5.11 Flexible Cable Systems

The supply to the crane for both cross travel power together with pendant cross travel connections, shall be by flexible round or flat-form cable systems suspended on trolleys sliding in galvanised track from the crane structure.

The trolleys shall be formed from stainless steel side plates and axles with nylon runners. Sufficient trolleys shall be provided to effect a maximum cable loop of 0.5m.

The cables shall be PVC insulated and flexible PVC sheathed type designed for the application, incorporating flexible stranded copper live and earth conductors, terminated in suitable junction boxes as specified with weatherproof glands designed for the cable shape.

303.5.12 Busbar Collector System

The power supply and earth connection for the long travel shall be from a current collector system of fixed busbar conductors which shall each be fully shrouded with PVC covers suitable for outdoor use.

The conductors shall be suitable for the current capacity, voltage drop and temperature conditions for the installation. Current collectors shall be of the sliding contact type with insulated contact heads mounted on spring loaded trolley arms. No current carrying surfaces shall be exposed.

303.5.13 Cable Reeling Drums

Cable reeling drums shall be of the spring loaded type which coils the cable radially about the drum axis and arranged for direct pulling off the drum, the core diameter being not less than the minimum bending radius of the cable. The springs of the drum shall be adequately rated to reel the useable length of cable fitted with the maximum tension applied shall not exceed the cable makers recommendation. Motor driven reels shall be provided where the spring loading is excessive.

The cable shall not overheat when used with the cable fully retracted. A totally enclosed slip ring connection box suitable for glanding the incoming supply cable, shall be fitted and the slip rings shall be rated to carry the full load current continuously and be accessible for maintenance.

Where specified, anti-condensation heaters shall be provided in the slip-ring enclosure, supplied at 240V AC or less from the appropriate slip rings via a fuse and link which shall be accessible without removal of the slip ring housing.

303.5.14 Trailing Cable

The trailing cable shall be 450/750V grade multicore type, designed to be suitable for use with a reeling drum. The size of the cable shall be such that a maximum recommended tension that may be applied to the cable is not less than the tension produced by the reeling drum.

Conductors shall be of flexible stranded copper, vulcanised rubber insulated with numbered tapes over each core. They shall be formed in a short lay round a flexible non-conducting centre core, sheathed overall with a textile covering and heavy duty PCP sheath.

Cable conductors shall be not less than 2.5mm² and sized so that they will carry the maximum full load working current involved without excessive voltage drop and take account of thermal de-rating in accordance with the IEE Regulations, as applicable to the particular drum and mode of cable winding.

In addition to any supply, control, or motor feed cores, the cable shall contain an earth core of size not less than that of the largest phase conductor.

NB. Cable material descriptions:

PVC Polyvinyl chloride (BS 6746)
EPR Ethylene propylene rubber (BS 6899)
CSP Chlorosulphated polyethylene
PCP Polychloroprene (propylene/chlorosulphated polyethylene)

303.5.15 Rail Bonding

Each section of running rail on the side adjacent to the supply isolator shall be bonded together and the rail connected to the earth terminal on the supply isolator by a protective earth conductor having a conductivity not less than that provided by a 4mm^2 section copper cable. The rail bonds shall be made by either of the following methods:-

i) Each section of rail is to be drilled near its end with a 7mm (9/32") hole.

An 8 SWG steel wire bond, galvanised to grade GLS400 to BS 182, is to be connected across each joint and secured at each end into the hole in the rail section by means of a tinned tapered steel pin which has a semi-circular groove along its length to hold the wire. The wire is to be overlength and the excess taken up by forming the wire into a 'Z' shape to absorb the expansion.

ii) For indoor locations, an overlength, 4mm^2 section of tinned copper braid, fitted with crimped lugs at each end shall be bolted to each rail end by means of brass bolts and washers of not less than 6mm dia.

303.6 ENCLOSURES

303.6.1 Definitions

The generic term enclosures shall be taken to mean any housing which encloses overall any items of plant or equipment. To distinguish between the different forms of enclosure, the following definitions shall be used.

a) Cabinets will be regarded as any wall or pedestal mounted, thermally controlled enclosure.

b) Kiosks shall mean any floor standing, thermally controlled, overall enclosure which may incorporate either an integral base or use the ground or floor slab as the base of the enclosure. The Kiosk shall be sized to permit man access for servicing the equipment within.

c) Shelters shall mean overall floor standing housing providing general weather protection without sealing or thermal control.

d) Housing shall mean the specific enclosure without thermal control for items of equipment, either located externally or within another enclosure.

e) Compounds shall mean areas enclosed by fencing or walls but generally exposed to the weather.

303.6.2 General

All cabinets and kiosks shall be fully weatherproof enclosures to IP 55, manufactured from maintenance-free, resin bonded, glass fiber reinforced, polyester (GRP) inner and outer skins, encapsulating not less than 12mm plywood reinforcement and insulation to give a `u' value of at least 1.5W/m²°C. The doors shall have flexible neoprene seals.

All cabinets, kiosks and shelters shall have doors incorporating steel reinforcement for rigidity and self-locking stays to maintain the doors open to at least 90°.

Door hinges shall be black epoxy coated, vandal-proof pattern with stainless steel pins. Locking door handles shall also be black epoxy coated steel with stainless steel cam action locking plates.

Where double doors are provided, shoot bolts shall be fitted to the top and bottom of the left hand door, central dead-locking of latch to right hand door to incorporate a security keyed `Yale' type lock to suit local key or other specified standards.

The closing edges of the doors shall have an external or internal overlap for weather sealing.

Ventilation to kiosks and shelters shall be provided either as under-eaves or via high level louvered vents protected by a fine mesh stainless steel/aluminium insect screen. Ventilation provided shall be equivalent to a 10mm continuous gap around the enclosure perimeter.

The interior shall be finished with a white based abrasion resistant vinyl paint. The exterior finish shall be GRP coloured Dark Green to BS 4800 (14 C 39) unless otherwise specified.

303.6.3 Cabinets

Wall mounted equipment cabinets shall have external fixing lugs and have removable gland plates fitted to the base for cable or pipework entry.

All cabinets shall have mounting rails bonded to the rear wall to facilitate equipment fixing and have an anti-condensation heater fitted. Outdoor mounted cabinets shall have a rear sloping top and a 50mm projecting drip canopy above the access door.

Inspection windows of toughened glass secured in a rubber gasket shall be provided where specified.

303.6.4 Kiosks

Where control panels are to be protected in outdoor locations they shall be enclosed in a cross ventilated weatherproof kiosk, sized to allow at least 1.0m clear working space in front of the panel. Battens shall be moulded to the inside walls to provide fixings for internal equipment and fittings.

The kiosk materials shall have a ½ hr fire resistance rating for retention of stability, integrity and insulation in accordance with BS 476 Pt 8.

Sectional kiosks shall be pre-assembled and fully sealed before delivery to site.

Fixing holes shall be provided in the base sections and the whole unit shall be fixed and sealed to the concrete base by means of a mastic compound applied before and after the kiosk sections are in place, to prevent ingress of moisture.

Kiosks shall be fitted with:

a) A suitable corrosion proof fluorescent light fitting, not less than 60 watt, so arranged to illuminate the face of the control panel complete with MK `Seal' On/Off switch inside the kiosk, wall mounted adjacent to the kiosk door, and wiring.

b) A suitably rated anti-condensation heater complete with thermostat, On/Off switch and wiring.

All electrical fittings to be connected by wiring in surface mounted PVC conduit to a 2 way metalclad consumer unit.

When space for the Electricity Supply Authority metering equipment and cut-outs is specified, a separate section within the main frame of the kiosk is to be provided complete with fire resistant chipboard panel. Details of size required and position in relation to the panel are to be obtained from the appropriate Electricity Supply Authority. Where specified, a lockable hinged door shall be provided to enable the meters to be read from outside the kiosk.

Where an external generator connection as specified, a small door or `cat-flap' shall be fitted opposite the panel mounted appliance inlet to provide access for a generator cable and connector. The door shall be large enough to pass the connector and it shall be horizontally hinged at the top, outward opening and lockable with a suitable padlock.

303.6.5 Shelters

Protection for plant requiring limited attention shall be of maintenance free materials, single skin GRP insulated panels or hot dipped galvanised steel panels with plastic skin external coating and alkyd paint interior. The shelter shall provide a degree of protection to IP44.

303.6.6 Housing

Field mounted electrical components and junction boxes shall be heavy duty industrial type, accommodated in totally enclosed hoseproof housings to IP65, of die cast, cast aluminium or rigid non-ferrous/polycarbonate materials having tapped conduit entries and recessed neoprene gaskets to seal the covers, the cover and housing fixings being outside the sealed area of the box.

303.7 COMPRESSORS/BLOWERS

303.7.1 Compressors

303.7.1.1 Air Compressors

Air compressors shall be air cooled capable of oil and dust free air delivery at the volume and pressures specified when directly or indirectly driven by an electric motor.

The compressor performance shall be in accordance with BS 1571 for the site condition and duty cycle specified and shall include the following components:

a) Suction air filter/silencer

b) Solenoid operated unloader valve

c) Pressure relief valve

d) Non-return valve

e) Isolating valve

f) Low oil pressure switch (if pressure lubricated)

g) Pressure gauge

h) Emergency stop push button

The equipment shall be suitable for operating in the climatic conditions detailed in the tender documents.

Where necessary, depending on load factor, the compressor shall include cylinder jacket and after cooler facilities for cooling the delivered air, the aftercooler having a suitable pressure relief valve and automatic drain valve.

303.7.1.2 Air Receivers

Air compressors shall deliver air into an air receiver manufactured in accordance with BS 5169 Class III Grade E or F, to accommodate the specified design pressure and internal volume.

Receivers shall incorporate the following items:-

a) One safety relief valve.

b) One automatic drain valve.

c) One pressure gauge (0 - bar).

d) Pressure and temperature switches to suit the control.

e) Inspection access to permit internal examination of the receiver.

f) Lifting facilities as determined by the receiver weight.

Receivers shall preferably be located in low ambient temperature areas to minimise condensation and the inlet and outlet pipe connections shall be arranged to promote air circulation.

303.7.1.3 Separators

The air distribution main shall include a separator designed to remove suspended moisture in the air main.

303.7.1.4 Compressed Air Filters

The air supply shall incorporate filters of the disposable element type as near as possible to the point of use.

Filtration shall be carried out using two filters in series, the first filter graded for course filtration and the second for fine filtration as defined in the Specific Requirements.

303.7.1.5 Drain Traps/Strainers

Automatic drain traps shall be provided for air receivers, filters and separators. Strainers shall be provided for protection of the drain traps. Ball traps shall have cast iron bodies with stainless steel internal parts (Spirax Sarco or equal).

303.7.1.6 Air Pressure Control

The compressor shall be arranged to maintain the air pressure in the system within the specified limits by means of pressure switches in conjunction with unloader valves and timers to prevent prolonged off-load running.

The frequency of starting and stopping shall be within the limitations of the drive arrangement.

Where two compressors are operated on a duty/standby basis, the duty compressor shall operate whenever the low pressure switch closes and shall cease operation when the high pressure switch opens. Should the pressure fall to the standby low pressure, the standby compressor shall operate in conjunction with the duty compressor and shall similarly cease operation when the high pressure switch opens.

The circuits for the compressor motor starters shall be completely separate. Either unit shall be capable of duty or standby operation and periodically their modes will be reversed.

303.7.2 Blowers

303.7.2.1 Air blowers

Blowers shall discharge continuously the specified free air delivery at specified suction and delivery pressures. They shall be suitable for automatic operation in all aspects.

Blowers shall be of the centrifugal or positive displacement rotary type capable of delivering oil-free air with high grade cast iron casings adequately ribbed to avoid distortion. The blower shall be fitted with mechanical seals and incorporate a mechanical oil lubrication system, including an oil flow indicator, level indicator, pressure gauge, filling and drain plugs.

The design of the blowers is to be such that the noise level is to be kept to a minimum.

The impellers shall have accurate contour. Impeller and shaft shall be made from one casting. Impellers shall be statically and dynamically balanced.

Impellers shall each be equipped with heavy duty spherical roller bearings at each end. Gear end bearings shall be axially located on the inner and outer races to control thrust and maintain factory set clearances at all times. Adequate facilities shall be made for the inspection of the rotors.

The two timing gears shall be of nickel cast iron or other approved material, accurately machined to position the impellers in the impeller case and shall be secured to the shafts by locking kits. Gears shall be enclosed in an oil-tight housing.

The shaft sealing arrangement shall comprise a garter spring viton lip seal and a piston ring seal with an intermediate space vented to atmosphere.

Gears and gear end bearings shall be lubricated by a splash oiling system from oil maintained in the gear housing. Drive end bearings shall be grease lubricated or lubricated by a splash oiling system from oil maintained in the drive cover, depending upon gear size.

Each blower is to be direct driven through a flexible coupling, or indirectly via `V' belts, by means of an electric motor, the complete assembly being mounted on a cast iron combination or fabricated steel base plate. Anti-vibration mountings and flexible pipe joints shall be provided. Both driver and driven units are to be dowelled or otherwise positively located to the base plate and substantial guards provided over all moving parts.

All covers and flanges associated with spigotted joints should be provided with easing screws if possible.

In view of high discharge air temperature, the Contractor shall install a protective barrier around all pipe work below 2.5m above blower room floor level.

303.7.2.2 Blower Accessories

Each blower shall include a tachometer, an adjustable weight operated lever type air relief valve, delivery pressure and suction gauges each with isolating cocks mounted on a panel secured to the blower. An automatic unloader vented to outside atmosphere or an approved by-pass system is also to be included if this will assist in starting.

The air relief valve is to be of double flanged cast iron construction with gunmetal trim. The adjustable weight shall have provision for locking to prevent any unauthorised interference.

Bosses shall be provided on each blower discharge pipe, upstream of the non-return valves, suitably tapped for connection by capillary tubing to pressure switches.

303.7.2.3 Blower Filters

The filters shall be capable of handling the designed throughput of air with the minimum of pressure drop whilst excluding 99.7% of all particles down to 2 microns.

The filters shall be of the two stage type comprising a hand operated roller mounted first stage roll type element and a disposable cartridge type second stage having access from one side only. The first stage unit is to be mounted in a galvanised sheet steel case with easily removable covers, the roller handle being conveniently positioned for easy adjustment of the roll. The second stage unit is to be mounted in a galvanised sheet steel case and the units connected by a transition piece, a further transition piece being arranged between the second stage and the silencer. Connections with isolation taps are to be provided on both sides of each stage and suitable manometers fitted to allow for measurement of the differential pressure.

Where required the suction of each blower shall incorporate an "in-line" air filter and silencer. The air filter shall be of the replaceable paper element type and shall be fitted with a differential pressure gauge with adjustable alarm contacts to initiate an alarm in the control panel on high differential pressure across the filter.

Each unit shall be supported from the floor on substantial steel frames with welded plate feet.

303.7.2.4 Air Silencers

Single inlet and outlet silencers shall be included for the blowers and manufactured of sheet steel, comprising a perforated inner tube and an outer galvanised casing, the space between being filled with a sound absorbing material. A flange is to be provided at each end, and all necessary supports extending to floor level are to be included. The silencers are to be designed for the minimum pressure drop.

303.7.2.5 Lifting and Handling

Blower units shall incorporate lifting eye bolts for ease of handling and installation/Removal.

303.7.2.6 Method of Control

Both manual and automatic control shall be provided for the blowers. A "hand-off-auto" selector switch shall be provided in the motor control and distribution panel.

In auto mode, the standby blower will alternate to duty position every 24 hours of operation.

303.8 DIESEL ENGINES

303.8.1 General

The engine shall be a cold starting 4 stroke water cooled, multi-cylinder in-line or "V" form, naturally aspirated or turbocharged and intercooled, totally enclosed industrial diesel of standard proven design, designed to run on liquid petroleum fuel to BS 2869 Class `A' and incorporate all starting, lubricating, cooling, monitoring, alarm and shut-down systems suitable for automatic and continuous unattended operation.

The engine crankcase shall be fitted with a breather pipe and safety devices to provide protection in the event of an explosion.

Crankcase access panels shall be provided for maintenance/inspection where possible.

Each engine shall be designed to operate with an ambient air temperature of 50°C and be capable of satisfactorily providing an output 10% percent in excess of the BS rating at the same speed for one hour in any period of 12 hours consecutive running.

All electric motors provided for ancillary equipment associated with the electric generation plant shall be of the squirrel cage type protected to IP55.

303.8.2 Duty and Rating

The engine shall be rated in accordance with BS 5514 to provide the necessary torque and power output at a rated speed not greater than 1500 rpm, to drive the specified load under the given site conditions.

303.8.3 Flywheel

The engine crankshaft shall be fitted with a flywheel of suitable inertia to absorb speed variation to within the specified limits. The flywheel shall incorporate all necessary barring facilities and timing marks. Safety devices shall be fitted to prevent the engine starting when any barring gear is in use.

The crankshaft shall be of solid forged steel statically and dynamically balanced to very close limits.

Hand operated barring gear shall be provided for each engine.

303.8.4 Torsional and Cyclic Characteristics

The rotating system of the engine and ancillaries shall be statically and dynamically balanced during manufacture. Detachable components eg. fans shall either be separately balanced or permanently marked in a manner that ensures correct angular positioning.

For alternator drives, the coupling between the engine and alternator shall be a flexible type of the manufacturer's standard arrangement and the torsional characteristics, cyclic irregularity, angular deviation and freedom from resonance shall comply with BS 4999, Part 142 and BS 5514 Part 5. The interchange of information between the engine and alternator manufacturers as directed therein shall be observed so as to ensure this.

303.8.5 Governor and Speed Control

The engine shall be fitted with a governor suitable for automatically controlling the engine speed in accordance with class 2 of BS 5514, Part 4. Provision shall be made for variable hand speed control, emergency manual shutdown and an over-speed trip arranged to cut-off the fuel supply.

Motor operated speed regulating gear shall be provided to enable the speed of the engine to be varied by 5% percent up or down from normal speed while in operation. The remote control for this regulating gear is to be operated from the switchboard.

303.8.6 Overspeed Protection

Overspeed protection shall be provided so that in the event of the engine speed exceeding 10% percent above the maximum operating speed an audible warning and indicator light shall be brought into operation, but should be speed still continue to rise to a figure of 15% percent above normal speed the fuel supply shall be automatically cut off and the engine brought to rest. The audible warning and indicator light, together with the other indicating lights and alarms specified hereafter, shall indicate on the monitoring panel in the alternator switchboard.

303.8.7 Air Intake

The combustion air for the engine shall be drawn from the area specified, through an air filter having elements of a type commonly available.

Where combustion air is ducted from outside the building, the duct entry shall be fitted with a coarse mesh and fixed louvres arranged to prevent the entry of debris, small animals and the products of inclement weather.

303.8.8 Fuel Systems

The engine fuel system shall consist of an engine mounted daily service tank, filters and fuel injection equipment with solenoid operated fuel cut-off valve, a gear driven mechanical high pressure fuel pump and isolating valves for the fuel supply to and from the service tank, all mounted adjacent to the engine.

Fuel leak off shall be piped back to the fuel filter assembly or the daily service tank. The high pressure fuel lines between the pump and injectors shall be sheathed to contain and return any spillage to the daily service tank. Such return pipework shall incorporate a reservoir chamber with a float switch to detect any accumulated leakage. Fuel atomisers shall be easily removable and interchangeable.

All fuel pipework on the engine shall be rigid tubing neatly dressed and clipped to avoid vibration or interference with maintenance procedures, have simple facilities for the relief of air locks and be spaced at least 50mm clear of any surfaces whose temperature exceeds 200°C.

Fuel filters shall be full flow type fitted with re-usable mesh material. For continuously running, base load applications, filters shall be twin or triple compartment type with a change-over cock to enable one cartridge to be removed for cleaning without stopping the engine.

303.8.9 Lubricating System

The lubrication system shall permit automatic starting of the engine and immediate load acceptance and consist of a wet sump with integral engine driven gear type pump providing forced lubrication to working parts through an oil cooler and a duplex full flow filter. The filter shall use disposable elements commonly available and be of adequate capacity to allow continuous periods of running without changing or cleaning.

Independent electric motor driven engine lubricating/pre-heating units shall be provided to give automatic periodic priming in accordance with the manufacturer's recommendation while the engine is at rest.

A hand priming pump shall also be fitted to enable all parts of the engine to be lubricated as required.

The cooling of lubricating oil on engines with engine mounted radiators may be by an `oil' section in the radiator. Engines with remote mounted radiators shall be provided with engine mounted water-to-oil heat exchangers for the cooling of lubricating oil.

The engine shall employ thermostatically controlled, liquid cooling using fresh water in a closed circuit, designed to suit the ambient conditions specified and comprise an engine driven circulating pump and a self-venting radiator. The pump shall also be capable of circulating sufficient coolant through the engine's lubricating oil cooler. Facilities for topping up and draining the system shall be provided together with a thermostat with a warming up by-pass.

Protected thermometers in suitable pockets shall be provided for measuring the temperature of the inlet and outlet cooling water and lubricating oil.

In addition to the overspeed alarm, protection devices shall be provided in the lubricating oil circuits and cooling water circuits to operate alarms and indicator lights, in the event of abnormal running conditions prevailing. These lights shall indicate on the remote monitoring panel. The engine shall shut down under alarm conditions.

A make-up header tank and automatic float valve shall be provided, together with all necessary connections to the specified supply source and the cooling system.

The cooling water shall include a quantity of anti-freeze to give protection to minus 10 degrees centigrade. An immersion heater and control thermostat shall be fitted to the system within the engine block to protect the coolant from freezing and shall operate from a 220V AC supply when the engine is not running.

Radiators mounted on engines shall be cooled by a `pusher' type engine driven fan which draws air from the vicinity of the engine block and discharges it through the radiator core. They shall also include a suitable mounting flange for the attachment of air duct trunking.

Remotely mounted radiators shall be cooled by an electric motor driven fan fed from an auxiliary generator directly driven by the engine.

If the engine cannot be fitted with a suitable direct driven coolant circulating pump capable of maintaining adequate circulation through a remote radiator, an auxiliary electric motor driven pump shall be provided. This pump shall be arranged to operate from the same supply serving the electric motor driven radiator fan.

303.8.10 Engine Cooling Equipment

Each engine shall be cooled by a bedplate mounted tropical rated radiator and cooling fan, adequately rated to maintain the normal working temperature, under continous, full load operation, working in conjunction with a pressurised water system, thermostatically controlled with centrifugal water circulating pump, valves and pipeworks.

303.8.11 Exhaust System

Each engine shall be fitted with a suitable exhaust system from the engine to the specified discharge point. The route shall be as short as site conditions allow and minimise the number of bends, which must be of large radius. The system shall include a primary residential type silencer, flexible and rigid pipework, roof cowl, flashing and all necessary ties and supports. The primary silencer shall be supported from the engine set and shall have a flanged outlet incorporating a flexible stainless steel bellows section for ease of disconnection from the remainder of the exhaust system. The exhaust system shall be insulated with a non-asbestos material. Removable cladding shall be provided on the exhaust system where specified.

Support brackets shall allow for pipe expansion and where the pipe passes through walls, a sleeve or wall plate shall be fitted with an adequate hole clearance to prevent wall damage or fire hazard. Pipe flanges shall be fitted on each side of the wall.

The interior of the pipework and silencers shall be metallic aluminium spray coated to BS 2569 Part 2 Class `D'. Where insulation is not applied, the exterior shall be similarly coated and shall be finished with a coat of high temperature aluminium paint from an approved manufacturer.

303.8.12 Fuel Oil System

A complete fuel oil systems including bulk storage and daily service tanks and transfer pumps shall be provided. It shall comprise steel, domed end horizontal cylindrical bulk storage tanks. Each tank shall be mounted on prepared foundations, and shall be complete with manholes, filling and draw-off connections, vent pipes and inspections holes an externally indicating contents gages. The necessary access ladder and platforms over the tanks shall also be supplied.

There shall be no gravity feed from bulk fuel tanks to service tanks, and no possibility of promonting and maintaining siphoning through fuel transfer pumps. All necessary valves

shall be included to ensure this. Service tank overflows shall be carried back to the bulk fuel storage to avoid any flooding of the engine room with fuel oil.

Arrangement drawings shall be supplied to illustrates the complete fuel supply system showing the position of tanks, valves, pumps and all other related equipment.

A single line scheme diagram of the system shall be submitted and of a form suitable for permanent display in the generator building.

An accurate fuel oil meter shall be inserted in each feed from the daily service tanks to the engines. These meters shall be in such a position to be readily readable.

Two filters shall be provided in the main fuel oil supply line with by-passes enabling one filter to be taken out and cleaned without interrupting the supply of oil through the other filter.

The whole of the fuel system including bulk tanks and daily service tanks shall comply with the requirements of painting and metal protection, finished colour as instructed by the Engineer.

A) BULK FUEL TANKS

A bulk fuel storage tank shall be provided or alternatively 2 tanks to provide the required storage volume and shall be manufactured and arranged with all ancillary apparatus to fit within the areas allocated on the Drawings. The size of tank(s) shall be such as to contain a sufficient quantity of fuel oil for operation at full load continuously as specified in the particular specifications.

The tank(s) shall be constructed of not less than 3 mm thick (nominal) plate which shall be free from imperfections and constructed as a rigid unit with internal partitions or bracing if necessary. The contractor shall submit for approval the calculation note justifying the selection of the final thickness to be adopted. The tank(s), or where it has more than one compartment, each compartment, shall be provided with a manhole and provision for ventilation to a single point shall be made.

All seams shall be continuously welded from both sides. Provisions shall be made to prevent damage to the tank bottom by impact from the dip-stick. For this purpose a welded stop collar shall be provided at the top of the dip-stick to rest on the manhole cover.

The dip-stick shall be of non-ferrous material accurately calibrated and clearly marked so as to be readily identifiable with its respective tank and shall be supplied, calibrated in liters, by the tank manufacturer.

The dip-stick tube shall be incorporated in the manhole cover, no separate tank opening being provided for this purpose.

Each tank shall be arranged for filling via a direct filling pipe which shall be positioned to give easy access for the delivery tanker. A minimum of 5% percent by volume of the tanks contents shall be allowed as ullage.

The filling pipe and dip-stick tube shall each have a liquid and vapour-proof screwed cap with captive chain and fitted with a lock with four keys.

The filling pipe and dipping tube shall be carried down to within 50 mm. of the tank bottom. The suction and return flow pipes shall terminate not less than 25 mm. above the bottom of the filling and dipping pipe so as to maintain a liquid seal.

A vent pipe not less than 75 mm. diameter shall be fitted to the highest point of the tank, and shall terminate with a wire cage for protective purposes (fine gauge shall not be used).

Each storage tank manhole shall be in an accessible positition and shall not be less than 600 mm. diameter clear opening. The manhole lid shall be securely fixed by bolts and have a liquid and vapour tight joint (close woven proofed asbestos graphited).

The outlet pipe shall be so arrange as to leave a minimum of dead space in bottom of the tank.

Each tank shall have connections to receive the excess flow from daily tank overflow.

Each tank shall also be provided with an externally indicating contents gauge marked in Arabic and English to read "full - 1/2 full - empty with intermediate tenths marking.

All openings shall be closed with steel plugs and blanking off steel plates bolted to flanges for transit to site.

The Contractor shall provide all details of his requirements for access holes, etc. required to the storage tanks to enable the constructive of the tank installations generally to the arrangement shown on the Contract drawings.

Bulk storage tanks shall have the internal and external surfaces descaled by grit blasting, pickling or other approved method. After descaling, external surfaces shall be given a phosphate coating followed by a cold water washdown. External surfaces shall be painted as specified. The interior shall immediately be oiled.

B) DAILY STORAGE TANKS

Each engine shall be provided with a free standing daily tank of sufficient capacity to allow 24 hours of continuous operation at full load and shall be provided with the following fittings :

i- Air vent of not less than 50 mm diameter.

ii- Overflow piping of not less than 150% percent diameter of the fuel delivery line.

iii- Cleaning handhole and cover of not less than 300 mm diameter.

iv- Contents gauge graduated in Arabic and English to read "Full - 1/2 ful - empty". The gauge shall be of the magnetically operated type and shall be complete with low and high level control contracts.

v- Outlet connection to engine not less than 50 mm above tank base.

vi- Fuel outlet isolating valve lockable in open position.

vii- Drain plug.

viii-Excess fuel return connection if necessary.

ix- Inlet connection from bulk fuel supply system including pipework and connections.

There shall be allowed a minimum of 10% percent of the volume of the tank contents as ullage. The top oil level of the tank shall not be less than 75 mm from the top of the tank.

Tanks prior to despatch from manufacturers works shall be tested hydraulically to a pressure 0.5 bars.

Daily tanks shall be complete with all supports and fixing bolts for mounting remote from engine base or skid mounted tanks will not be accepted.

There shall be provided all necessary fuel oil pipework, unions and valves between the day tank and the engine.

Fuel connecting pipework to engine shall be seamless steel and all pipes shall incorporate flexible section, if not less than 250 mm long (plastic pipes or fittings are not acceptable).

C) FUEL TRANSFER PUMPS

Adjacent to each daily service tank there shall be provided an electrically driven fuel transfer pump operating in conjunction with the control switches fitted to the daily tank contents gauge. The pump shall be of the positive displacement type rated at a capacity to enable the associated daily tank to be completely filled from empty within 2 hours. The pump motor shall be in accordance with section four and suitable for 380 volts, 3-phase, 60 Hz operation. Automatic control shall be provided for each pump, via the control contacts fitted to the associated fuel contents gauge, to maintain a minimum of 24 hours fuel storage in the daily tank. A semi-rotary, hand operated pump shall be installed and connected in parallel with each electric pump. Both pumps shall be completed with a minimum of 4 m of flexible nose and a two position hand valve to enable the pumps to extract from the bulk fuel tank or, if necessary from a portable drum situated adjacent to the daily service tank.

D) WARNING AND SAFETY DEVICES

The following warning notice shall be supplied and fixed in a prominent position in the vicinity of each bulk fuel tank with 50 mm plain block black letters on a yellow background, printed in Arabic and English.

NO SMOKING

DIESEL FUEL - HIGHLY INFLAMMABLE

Additional notices shall be provided in accordance with the labels signs and notices requirements. The wording of the notices shall be subject to the Engineer's approval.

303.8.13 Fire Cut-off Valves

Fire cut-off valves shall be incorporated in the fuel delivery pipe to each engine from the daily service tank and be located in an accessible horizontal position, coil uppermost, close to the tank.

The valves shall be manually operated and solenoid maintained in accordance with BS 799 Part 7, the solenoid will be arranged to release in the event of a fire signal. The emergency handle shall be labelled with a conspicuous permanent notice reading:

"FIRE VALVE-PULL LEVER DOWN TO ISOLATE FUEL SUPPLY.
LIFT TO RESET".

Where specified, a dump valve shall be fitted in the pipeline immediately beneath the daily service tank so that the tank contents can be returned by gravity head to the bulk storage tank or a suitable external dump tank in the event of a fire signal. Electrically operated valves shall open when the operating solenoid is de-energised.

Fire detection devices shall be installed in suitable locations for alarm and signalling.

303.8.14 Engine Starting

The engine shall be arranged for automatic starting and stopping arranged in conjunction with the overall control system. The engines shall not require pre-start priming of lubrication and shall be arranged for instant starting by batteries or compressed air as specified, the starter motor(s) engaging with the flywheel ring gear and disengaging automatically when the engine starts. The system when fully charged, shall have sufficient capacity to crank the engine when cold, for at least 10 consecutive 15 second periods at 20°C. A self contained charging system shall be provided to meet these requirements.

Batteries shall be of the heavy duty, 24 volt, lead acid type complete with charger, housing cabinet and necessary interconnecting cable.

Each battery charger shall be connected to the main motor control center board in the control room.

303.8.15 Engine Instruments

An instrument panel shall be resiliently mounted on the engine complete with the necessary piping, connections, isolating cocks and indicators for the following:-

- Cooling water temperature
- Lubricating oil temperature
- Lubricating oil pressure
- Revolutions per minute
- Exhaust temperature at each cylinder outlet
- Running hours totaliser (showing 5 digits & non-resettable).
- All instruments shall be scaled in approved metric units and gauges shall comply with C1 5.1.3 - Indicator gauges.

303.8.16 Engine Protection

The engine shall be provided with alarm and shutdown features as specified in Volume 3, Part 4 - Electrical Works. Shutdown conditions shall be arranged to operate through the fuel solenoid.

A manual fuel rack release knob shall be provided for emergency use.

303.8.17 Engine Wiring

All wiring for engine mounted electrical components shall be carried out in suitably rated heat and oil resistant cabling fixed to the equipment where necessary and terminated in a wiring terminal box or boxes mounted in an accessible position on the bedplate, suitable for the necessary cabling to be extended to the local control panel. Separate boxes shall be provided for AC and DC circuits.

For full details of terminal boxes and auxiliary switches see Volume 3, Part 4 - Electrical Works.

303.8.18 Engine Mounting Arrangement

Engine driven sets shall be either close coupled or open coupled as specified, via a flexible coupling. The driven unit shall have two independent bearings and all major items of the rotating assembly shall be dowelled to preserve alignment.

Close coupled sets shall be secured through anti-vibration mounts to a substantial fabricated steel base fixed to the floor.

Open coupled sets shall be fixed to a substantial fabricated steel base frame, secured direct to the floor, or where specified, secured through anti-vibration mounts between the base frame and floor.

The base frame shall be structurally designed and constructed to ensure maximum strength and may be used to mount engine ancillaries, set wiring marshalling boxes and control panels. The frame shall include jacking facilities where anti-vibration mountings are used. These shall not project to cause hazards to operating personnel.

Anti-vibration mountings shall be multiple neoprene bonded pattern, arranged to distribute without resonance the total weight and dynamic loads of the assembled engine set and auxiliaries supported on the base frame.

303.8.19 Drip Tray

A drip tray, complete with drainage cock, shall be fitted within the confines of the baseframe and shall have a capacity at least equal to that of the lubricating oil contained in the engine.

303.8.20 Noise Attenuating Enclosure

The enclosure shall be removable pre-fabricated type designed to reduce the noise level by approximately 20 dB(A).

The enclosure shall incorporate access doors or panels such that routine maintenance can be carried out without removing the entire enclosure. It shall be possible to remove the enclosure without disconnection of the silencer mounted outside the enclosure. The operating sound pressure level of the set, measured in accordance with BS 4196 at a distance of 3 metres, with the exhaust silencer and the noise attenuating enclosure in position, shall be as elsewere specified.

The Tenderer shall state**,** the predicted sound pressure level of the plant under the specified operating conditions, with and without the noise attenuating enclosure fitted.

303.8.21 Ventilation Equipment

Each of the generator rooms shall be provided with fixed, sand-trap type, inlet louvres to allow passage of cooling and aspiration air necessary, during the generator operating periods. Inlet louvres will be supplied and fitted by the civil Contractor. However, the Contractor shall provide and install for each generator set an automatically operated, cooling air exhaust louvre complete with flexible ducting for connection between the radiator and louvre flange. Each louvre shall provide a weather proof seal during non-operating periods and arranged to automatically open on generator start-up, each louvre shall be supplied complete with a matching "bird-guard" wire mesh frame for installation on the exterior wall of the generator room.

Louvres and bird-guards shall be manufactured from aluminium and the Contractor shall advise the size of clear opening required for the extract louvre and confirm the sizes of inlet louvres for the required duty. The ambiant temperature of the generator rooms shall not exceed 40 °C.

303.8.22 Steelworks

The following steelwork shall be provided and fixed in accordance with metal protection and painting requirements.

i- Support frames and access platforms for fuel storage tanks.

ii- All necessary pipe supports.

iii- All ancillary brackets, clamps, etc.

303.8.23 Pipework

All fuel pipes and fittings shall be of seamless stainless steel, all valves shall be cast steel, and designed for the duty they are required to perform. Galvanized pipework and fittings shall not be used for any line handling fuel. All pipeworks shall be fully supported and complete with all brackets and fixings.

Pipework installations shall be carried out for the various items of plant, equipment and shall include : -

i- All pipework and valves from the bulk storage tanks to the daily storage tanks and filling point.

ii- For the bulk storage tanks.

1 No. easily cleaned filter.

2 No. shut off hand operated valves (one each side of filter).

iii- The main fuel line from the bulk storage tank installation shall be fitted with fail safe quick closing emergency valve with replaceable fusible link arrangement to shut fuel off in event of fire. The operating temperature of the heat sensitivity element shall be 93°C.

iv- One complete set valves for each set of fuel transfer pumps comprising suction and delivery isolating valves, non-return valves and pressure relief valve with return pipe.

v- Overflow pipework and fittings from each daily tank to the bulk storage tanks.

The pipework installation shall comply with the general protection requirements. Finish colour shall be as instructed by the Engineer.

303.8.24 Stop Push Button Stations

Local "Emergency Stop" push button stations shall be provided.

Each generator set shall be provided with 1 No. emergency stop push button station, suitably positioned at the end of the generator set assembly.

303.9 FLUMES

Flume formers shall be provided for construction of concrete flumes by the Civil Contractor. The liners shall be a matched pair and a locating jig shall be included to ensure correct installation in the channel. The liners shall conform to BS 3680: Part 4C: 19/4. (Level shall be measured by an ultrasonic measuring system, the detector head to be mounted over the channel. The requirements for ultrasonic level detectors are specified separately.)

303.10 WEIRS (VEE NOTCH OR STRAIGHT WEIR)

Weir plates shall be manufactured from stainless steel or non-ferrous material suitable for the liquid being measured. The weir plate shall be mounted on a fabricated mild steel plate for fixing into the weir chamber. The mounting plate shall be sealed where it fits into the chamber and against the weir plate. The weir plate fixings shall be slotted to allow adjustment on site.

The weir and Vee-notch weir plates shall comply with BS 3680: Part 4A.

Thin plate weirs will only be used on sediment free water.

304. PUMPS

304.1 GENERAL REQUIREMENTS

304.1.1 Materials

Materials of construction of pumps shall be in compliance with the following requirements unless otherwise specified in the Particular Specifications. Other materials of superior quality may be used subject to the approval of the Engineer.

TYPE OF USE	RAW WATER	DRINKING WATER	SEWAGE	HYDROCARBON	DRAINAGE
CASING	NI-RESIST	CAST IRON EPOXY COATED (150 μ) OR SS 316L	CAST IRON	STEEL	CAST IRON
IMPELLER	NI-RESIST	ZINC FREE BRONZE (MAX 3% ZINC)	CAST IRON	STEEL	CAST IRON
TRIM	NI-RESIST 316 L	ZINC FREE BRONZE (MAX 3% ZINC)	CAST IRON	CAST IRON 13 CR	CAST IRON
MECH.SEAL	MANUFACTURER STANDARD	MANUFACTURER STANDARD	MANUFACTURER STANDARD	MANUFACTURER STANDARD	MANUFACTURER STANDARD
STUDS	ASTM A193 GRADE B7	ASTM A193 GRADE B7	ASTM A193 GRADE B7	ASTM A193 GRADE B7	ASTM A193 GRADE B8M
NUTS	ASTM A194 GRADE 2H	ASTM A194 GRADE 2H	ASTM A194 GRADE 2H	ASTM A194 GRADE 2H	ASTM A194 GRADE 8M

304.1.2 Pump Units

All pump units shall have means of isolation from their associated pipework system.

In dry well installations, the suction valve will normally be left open, unless used for isolation when the pump is out of service.

The delivery side of the pump set shall include a non-return device to prevent back circulation when the set is not running. This shall be a fail-safe device such that in the event of pump failure or loss of external services, the device shall independently close eg. ball valves, check valves or gate valves closed by gravity or stored energy systems in exceptional circumstances. A gate valve will normally also be installed on the pump delivery side, downstream of the non return device, for pump isolation.

304.1.3 Pump Unit Control

The pump unit control panel shall include all control and indication elements for the pump motor, together with any associated valve actuators, lubricating systems and valves, cooling fans, flushing pumps and other ancillary control equipment required by a pump drive, all arranged to operate in a safe and proper sequence.

Where external services are required to open the delivery valve, the control system shall initiate the valve opening procedure as soon as the pump is up to a speed sufficient to overcome any existing delivery pressure.

Normal starting sequence will therefore cause the pump to run-up to operating speed then initiate opening of the delivery valve. Normal stopping sequence will first initiate delivery valve closure, after valve has closed then pump motor will be de-energised.

Failure of the valve to open within the time allowed, or closure occurring whilst running, shall initiate an alarm and shut down the pump set. The maximum running time with the delivery valve closed shall be 3 minutes unless otherwise specified.

304.1.4 Pump Duty

Pumps shall be of the type specified in the PS. They shall be designed to give specified output against all losses including those relating to the pump.

The Contractor shall match his pump characteristics to the pipe system network to achieve high pump efficiency and reliability.

Each set must be capable of running satisfactorily in parallel with other sets in the system without throttling and by itself, without cavitation or overload under all operating conditions within the system characteristics given.

The pump section and arrangement shall be such as to ensure that the head available exceeds the N.P.S.H. requirements of the pump under all operational conditions.

Where the system and pump characteristics are such as to give rise to the possibility of surge in the pipeline with consequential damage, a surge investigation shall be undertaken; if the results of the investigation show that there is a problem, measures shall be proposed by the contractor to alleviate the problem. These measures shall be agreed with the Engineer.

Centrifugal pumps shall have a non-overloading characteristic over the complete range of head and quantity delivered and the drive shall be capable of starting the pumps against a closed valve, ie. maximum pump head conditions.

The whole pumping unit shall be capable of withstanding without detriment, reverse rotation to a speed that would occur if the pump were to stop when the differential head was at a maximum and the delivery and/or non-return valve failed to close.

The design of the pumps shall be such that there will be no tendency to unlock any part due to possible reversal of rotation and shall not pass through or approach a critical speed.

The pumps shall be capable of working for long periods without cleaning or attention.

For sewage pumps the ability to operate with the maximum reliability is of prime importance, with efficiency being a secondary consideration. The pump shall operate without clogging, being designed to pass a sphere as specified in Particular Specification (PS) where the size of the delivery mains permits. Whilst the pumps shall be designed to meet a specific duty they shall also be capable of operating over the duty range specified for prolonged periods and for standing idle for long periods without attention as in the case of storm pumping.

304.1.5 Pump Duty Control

Each of the pump units shall be capable of operating in any combination of duty sequence.

Any starting sequence, including those following restoration after a supply failure shall be time sequenced to prevent excessive load on the supply system. Each duty circuit shall include its own timer, arranged to be initiated in the selected duty sequence by the preceding duty, the delay periods between each re-start being adjustable up to 20 secs.

Pumping sets shall be automatically operated according to water levels in the discharge and suction side reservoirs unless otherwise specified.

Successive levels shall be carefully chosen in order to ensure a smooth and safe operation of the pumping system, taking into consideration the characteristics of the pumps, networks, hydraulic inertia of the installation, as well as the sensitivity of the instrumentation.

Two sets of level measuring devices operating in redundancy shall be installed in each reservoir unless otherwise specified.

Where valves with motorised actuator are installed on pump outlet pipe section, the pump shall be started with a closed valve: each pump shall start when the valve is still closed. The valve begins to open at the starting command of the pump and shall be controlled by the discharge pressure. The time of the total opening of the valve shall be chosen according to the pump manufacturer recommendation. At the pump stop command, the corresponding valve shall receive a closing signal and shall close fully prior tot he shutdown of the pump.

Where more than one pumpset is installed for a water network and unless otherwise specified, pumps shall be operated with a cyclic duty program automatically executed by the supervisor system. However, a selection of pump duty order by the operator shall be possible.

304.1.6 Pumps Casings

Pump casings shall be capable of withstanding all pressures which may be produced due to operating pressure surges.

Particular attention shall be paid to the wear characteristics of the pumps. In the case of sewage pumps, due to the presence of grit in the sewage wear, could be appreciable.

The pump design shall ensure that alignment is maintained between the various assemblies by recesses, spigots and dowels and shall be such that all components liable to wear can be replaced.

Components shall be permanently marked with the manufacturer's number and where dowels are not used, permanently marked for correct assembly. The pump casing shall have detachable wear rings.

The casings of the pumps shall have flanges to match the specified pipework.

The waterways through the pumps shall be smooth in finish and free from recesses and obstructions.

Sewage pump casings shall be of substantial construction to give long life under abrasive conditions and suitably stiffened to withstand shock due to solids in suspension. Inspection

holes shall be provided in any section bend and in the pump casing above the impeller for access to facilitate the clearance of obstructions. The inspection hole covers shall be shaped to conform to the interior profile of the waterway when in place and shall be fitted with starting screws where necessary.

304.1.7 Impellers

Impellers shall be securely fitted to pump shafts in such a manner to prevent them becoming loose or detached when the pump is in operation, or when rotating in the reverse direction, either by liquid flow or motor rotation.

The impellers and guide vanes (if any) shall be accurately machined and smoothly finished to minimise hydraulic losses.

The rotating elements type shall be specified in the PS and shall be statically and dynamically balanced before final assembly.

For sewage pumps the impeller shall be of the open type with the inlet ends of the vanes being of bulbous design and the impeller passages being as large as possible consistent with good performance. The impeller shall be readily withdrawable from the pump casing without the need to disconnect pipework. The inlet ends and surfaces of the vanes shall be dressed to give a smooth finish to prevent fouling by rags and fibrous matter within the pumps.

Impellers for both sewage and storm water pumps shall be of the non-shrouded type, constructed as specified in the PS, and designed to exclude gritty matter from the shaft and gland.

The impellers should have replaceable wear sings. The clearance at the wear rings shall be kept to a minimum, and where it is found necessary to cut back the impeller this is to be done on the vanes only.

304.1.8 Pump Shaft

The pump shaft shall be as specified in the PS adequately sized, with good fatigue, shock load and corrosion resistance. The duty speed range shall be well below the first critical speed of the shaft. Where a change in diameter of the shaft occurs the shoulder shall be radiussed or undercut to the appropriate BS to reduce stress concentration.

The shaft shall be complete with easily renewable protecting sleeves of suitable material (stainless steel) at glands and bearings.

304.1.9 Shaft Seals

Pump shaft sealing type shall be as specified in the PS.

Pump shaft sealing arrangement shall be suitable for the water pressures and shaft speeds involved.

Pumps shall be fitted with packing glands seals or a split type mechanical shaft seal arranged such that replacement of wearing components can be carried out without the need to dismantle the pump.

Special care in the selection of materials shall be taken in order to avoid binding and electrolytic action between the shaft sleeve and the mechanical seal components, particularly where long periods of idleness are inherent in the duty cycle as in the case of standby and storm pumping.

Each mechanical seal shall be equipped with leakage collection facilities and separately piped as specified.

Pump glands shall be of the soft packed type with wearing sleeves and shall be designed for grease lubrication and shall be provided with large size grease lubricators with tell-tales. Glands and lantern rings shall be of the split type to facilitate easy packing.

Pumps fitted with soft re-packable or packed gland type seals, shall have stuffing boxes designed to facilitate adjustment or replacement of the packing materials.

304.1.10 Bearings

All pumps shall incorporate bearing arrangements which prevent the escape of lubricant into the liquid being pumped. The bearings shall be located in dust/moisture-proof housings.

All bearings shall be liberally rated to ensure cool running and meet the load factors specified.

For vertically mounted pumps, the top bearing shall be a combined thrust and journal type, designed to prevent any thrust loads being transmitted to the drive motor. The pump bottom bearing shall be lubricated by an enclosed water lubricated sleeve bearing for potable water applications but by grease or other approved means for sewage use. Storm pump bearings shall also be suitable for standing idle for periods up to 2 months without attention or movement.

Where grease points are necessary they shall be fitted with removable screwed plugs which shall be accessible without removing guards. All bearings having automatic lubrication shall also have provision for hand lubrication.

304.1.11 Baseplates and Stools

For vertical pump units, heavy cast iron or fabricated steel floor plates and motor stools shall be provided for direct mounting on concrete floors or supporting steelwork. Suitable journal and thrust bearings shall be provided in the baseplates to carry the vertical drive shaft.

Where necessary the motor stools shall be designed to accommodate flywheels and bearing housings.

Floor plates shall be recessed and so arranged that the tops and fixing bolts are level with the finished floor.

The pump units shall be accurately aligned and located on the baseplate by set screws and parallel dowels or machined spigots. Approved means of dowel withdrawal shall be provided.

304.1.12 Lubrication/Cooling Monitoring

A lubrication system shall be arranged for the lubrication of all grease points on the pumps and shafting from motor room level. Individual bearings within the support tunnel tubes and on the

pump sets themselves shall receive separate supplies of grease fed by pressure tubes laid from each bearing to battery plates readily accessible from motor floor level for grease gun operation.

Pressure tubes shall be grouped together where possible and securely attached by brackets, straps etc. to tunnel tubes, with connectors located near to the motor support plate for easy removal of shafting in the event of maintenance work. In exposed positions pressure tubes are protected from damage. Motor grease points will not be included in this lubrication system but shall receive individual attention.

The battery plates shall have sufficient greasing points for all bearings and be located on or adjacent to each pump motor stool.

A notice is to be supplied and fixed on the wall in a prominent position detailing the manufacturer's recommended greasing schedule. The notice shall include a warning of the dangers to bearings from `over greasing'.

A grease gun shall be supplied for all greasing purposes.

Bearings which require a continuous supply of lubricant shall incorporate a means of monitoring such a supply, either by flow or temperature rise as appropriate for the type of bearing employed; separate monitors being fitted for each bearing feed or housing.

Such monitors shall include all necessary ancillary power or pulse counting devices to enable the operation of any monitor to initiate a volt free contact rated at 240V 0.5A AC.

304.1.13 Pump Tundish

Where specified, each pump shall be equipped with a cast aluminium or fabricated steel tundish to accommodate the drain lines from mechanical seals, casing vent and other minor drainage points on the pump. A single drain pipe shall be run from the tundish to the house drainage system.

304.1.14 Air Release Cock

The highest point on the pump casing shall be fitted with a manual air release cock having a removable handle or an automatic air release valve with a lockable isolation valve as specified. Air release pipework on sewage pumps shall be not less than 30mm bore and shall discharge back into the wet well at high level and have facilities for rodding. The drain from each air release cock shall discharge via pipework as specified.

304.1.15 Couplings

Coupling materials shall be chromium stainless steel.

All couplings shall be of an approved type and the Contractor shall arrange for the provision and fitting of both coupling halves to each respective shaft and shall include for all necessary modifications to any existing shafts to be coupled.

Where specified, the Contractor shall include any equipment required to prevent damage to any part of the drive in the event of reverse rotation of the pumps.

304.1.16 Intermediate Shafts

Intermediate shafts between the pump and drive shall include universal couplings at each end allowing free axial movement to avoid end thrust being transmitted. The shaft and coupling shall be fitted with a full length guard manufactured from mild steel mesh on a mild steel framework, easily removable for maintenance purposes.

The frame and mesh shall be hot dip galvanised.

304.1.17 Gear Unit

Each unit shall be continuously rated to transmit the full power of the drive either directly in line or through a right angled, helical gear system, having an input/output speed ratio to suit the duty. The gear case shall be made of substantially ribbed cast iron with machined mounting feet and shall form a totally enclosed, oil tight casing.

The gear unit case and bearings shall be designed to accommodate the total weight of any suspended drive shafting and couplings in addition to any dynamic load imparted during service, and run for a minimum of 10,000 hours before a major overhaul is required.
Where specified, an electric tachometer shall be fitted to indicate the output shaft speed.

(i) Lubrication

The gear unit shall be grease or oil lubricated, arranged to provide an adequate supply of lubricant for the duty.

Where oil lubrication is employed, the casing shall include an oil breather, level indicator and drain plug.

Units having a rated output greater than 500kW shall have inspection covers and include a forced lubrication system comprising an oil circulating pump, reservoir tank and full flow `Duplex' type oil filters having re-usable elements together with associated pipework; the oil being circulated by either (a) an internal mechanically driven gear pump and an external electrically driven pump arranged to prime the gears as pre-set timings as recommended by the unit manufacturer, or (b) duplicate external electrically driven pumps, each of which may be selected to prime at pre-set intervals and run when the gear unit runs.

Such a lubrication system shall include dial gauges and alarm switches to monitor high oil temperature and low oil pressure.

(ii) Reverse rotation

Where specified, the gear unit shall be capable of withstanding reverse rotation for a limited period with no detriment to the unit. Where a forced lubrication system is used, this shall continue to operate satisfactorily under such conditions.

304.2 SUBMERSIBLE PUMPS FOR SEWAGE & RIVER WATER APPLICATION

The pumps shall be fully submersible and of the unchokeable type, capable of passing raw unscreened sewage. They shall have non-overloading characteristics and incorporate bearings sealed for life.

The sealing arrangements between pump and motor shall be by means of mechanical seals running in an oil bath which serves to lubricate and cool the interfaces of the seals.

The pump shall include renewable and easily replaceable wear rings.

Robustness of construction and the ability to operate automatically with a minimum of attention for long periods is essential.

The pumps shall be supplied with guide rails unless otherwise stated, and particular attention shall be given to the free passage of the pumps up and down the rails without jamming. The pump outlet flange, unless otherwise stated, shall have a boltless coupling on to the flange of the fixed delivery pipework and shall have positive location so as to provide an automatic coupling with a good seal when the pump is lowered into position.

The pump casing shall incorporate a lifting eye of not less than 80mm internal diameter suitable for the attachment of heavily galvanized lifting chains which shall be brought out of the wet well to a conveniently sited fastening. For electrical details, see Volume 3, Part 4 - Electrical Works.

Unless otherwise specified, sewage pumps shall be equipped with a flushing system that shall stirr the water in the sump prior to the start of the pumping cycle. The stirring shall be effective by putting sludge and solid particles into suspension and shall prevent the build up of sludge banks and debris on the sump floor.

304.3 PROGRESSIVE CAVITY PUMPS

The pump casing shall be manufactured in a close-grained cast iron in accordance with BS 1452, or in grades of stainless steel to suit the nature of the pumped liquid. The pump casing shall be pressure tested in accordance with BS 599.

The pumping element shall consist of a single helical rotor revolving within a resilient stator. The stator/rotor shall be designed in accordance with the normal operating conditions, taking into consideration temperature, corrosion, abrasion and reliability under maximum torsional load. The rotor material shall be stainless steel either ceramically coated or chrome plated in accordance with the relevant requirements of BS 970: Part 1.

The rotor's eccentric motion shall be facilitated by either a flexible drive shaft or by fitting a universal joint between the motor and drive unit. This motion shall permit a continuous seal line throughout the pumping element thus giving a constant positive displacement. The flexible or coupling rod drive shall be of a high strength stainless steel with an impermeable thermoplastic or equal coating to provide resistance to abrasion and corrosion.

The pump drive assembly may be directly coupled or arranged for a guarded toothed-belt drive arrangement. The pump speed shall not exceed 500 rpm.

Under no circumstances shall any grade of aluminium be employed in the fabrication of the pump's wetted parts.

All working surfaces shall be accurately machined and provided with deep registers, where necessary, to ensure true accurate alignment. The pump casing shall be capable of being fitted with a replacement rotor and stator components. Tapped bosses shall be provided for drainage purposes and suction and delivery gauge connections.

304.4 SCREW PUMPS

Screw pumping units shall be suitable in all respects for pumping crude sewage and returned activated sludge and for running continuously at all outputs up to the specified maximum. All parts and components shall be fully weather-proof and suitable for use out of doors.

i) Drive Arrangement

Each pump shall be driven by an electric motor, the drive being transmitted from the motor to the screw, either directly through a reduction gearbox or else through a V-belt drive and gearbox.
The gearbox shall have oil bath lubrication and shall be provided with an inspection cover, oil breather and oil level indicator. The gears shall be rated for continuous duty.

Connection between the drive unit and screw shall be by means of a pin-type flexible coupling with rubber bushes, or other approved flexible coupling.

If a V-belt drive is used ready means of belt tension adjustment shall be provided.

Means shall be provided to prevent reversal of rotation on shut down.

ii) Bearings and Lubrication

Each pump shall be complete with top and bottom bearings, driving mechanisms and automatic lubricators, all supplied and installed as a unit by one manufacturer.

The top bearing shall be designed to accommodate the main radial and axial loads which occur on the screw and shall be suitable for high pressure grease lubrication. The bottom bearing shall be of the bronze sleeve type secured in a watertight cast iron housing and designed to accommodate radial forces and end support load. The housing shall be mounted on a fabricated steel pedestal and plate which shall be swivel mounted to allow them to take up correct alignment on installation. The bearing shall be fitted with an external stationary shroud to prevent debris affecting the moving parts.

Lubrication shall be automatic from a grease or oil lubricator, the lubricator pump being driven by an electric motor or from the main drive. A friction drive is not acceptable. A `tell tale' indicator in the case of grease, and flow indicator in the case of oil, shall show that lubricant is passing to the bearing. Oil shall be returned from the bearing to the oil reservoir.

In the case of an electrically driven lubricator the electric drive shall be interlocked with that of the main pump drive so that the screw pump will not run without the lubricator. A warning light

shall indicate `lubricating pump failed'. Where other means of driving the lubricator pump are used provision shall be made to stop the screw pump if the lubricator drive fails for any reason.

iii) Installation and Guards

Each screw pump shall be suitable for mounting in a concrete trough and shall be supplied complete with steel side profile member. Each screw shall also be supplied with a steel splash plate to fit round the shaft and seal the hole where the upper end of the screw passes through the wall into the motor room. The screw and its driving mechanism shall be such that they can be safely used to form the final screed of the concrete trough in which the screw rotor runs.

All equipment offered shall be designed to keep maintenance to a minimum, and to provide maximum safety to operatives and maintenance staff. Protective guards shall be fitted over all moving parts to prevent any possible contact.

304.5 DOUBLE DISC PUMPS

The double disc pump shall comprise two reciprocating, mechanically driven, tough resilient discs with a sufficiently large cavity between the discs to produce displacement in a smooth continuous flow.

The pump shall be valveless and glandless and be capable of operating dry indefinitely without pump damage occurring.

The double disc pump shall be available as a static or mobile unit, as specified. It shall be suitable for either electric motor or diesel engine drive, as specified.

The pump body shall be manufactured from cast iron to BS 1452 Grade 220, as a minimum.

The discs shall be manufactured from Nitrile rubber or equivalent.

304.6 DIAPHRAGM PUMPS

The pump shall be of the diaphragm type utilising a bullfrog type valve, suitable for pumping viscous solutions containing solids up to 55mm diameter as specified. It shall be driven by an electric motor through an oil bath reduction gear unit.

The main body of the pump shall be manufactured from LM6 aluminium and all wetted parts shall be supplied in 316 stainless steel.

The diaphragm shall be manufactured from neoprene, nitrile, hyperlon or viton elastomers and shall be reinforced with polyester fabric.

304.7 SUBMERSIBLE BOREHOLE PUMPS

Pumps impellers shall be closed or semi open type.

Pump body shall be treated against corrosion. The bowls shall be joined by flanges or by tie roads.

The shaft main guide bearings located in the suction and delivery end housings of the pump shall utilise a leaded-bronze material, and shall be provided with protection guards to prevent ingress of sand and grit. Pump bowl guide bearings shall utilise either leaded bronze or other approved abrasion resistant material. All pump bearings shall be lubricated by the water to be pumped. The pump delivery end housing shall incorporate a thrust washer of suitable material at the shaft end to absorb upthrusts that occur during pump starting. Unless otherwise specified, the pump shall incorporate a delivery check valve of hydrodynamic shape fitted with a spring to prevent reverse rotation of the shaft from back flow of water through the pump. The pumps shall be provided with a flanged discharge connection suitable for operating against the pump closed valve head or 16 bar whichever is the greater. The shaft coupling connecting the pump and driving motor shall be accurately machined and keyed to ensure precise shaft engagement and alignment. A strainer of suitable corrosion and abrasion resistant material, designed to guard against entry of foreign matter but permitting unrestricted flow of water into the pump, shall be provided on the pump suction housing.

Protection against the effect of sand shall provided by renewable wear rings (made from a hard smooth flexible material such as polymethane) mounted at the seating of the impellers and the passages of the shaft.

The pump shall be designed to pump water having a sand content of up to 40g/m3, unless otherwise specified

A centraliser shall be fitted to every pump to ensure central alignment of the pumpset in the borehole casing.

304.7.1 Borehole Pumps Rising Column

Borehole rising column shall be seamless steel and provided in section lengths not exceeding 3 metres with flanged joints or screwed couplings according to API5L grade B or equivqlent. The rising column shall allow for small deviations in borehole verticality. Cables and and water level dip tubing shall be securely fixed to the rising column by straps or bands at approximately 2 metre intervals.

The rising column shall be sufficient to take the stresses generated by the hanging weight of the pump, motor and rising column, the stresses produced by the water pressure together with any dynamic stresses which may occur under any circumstances including valve closure.
The rising column shall be protected internally and externally in factory against corrosion by a non toxic epoxy resin coating (300 μm minimum thickness) suitable for use with potable water.

304.7.2 Borehole Pumps Headworks

A fabricated steel discharge head piece shall be provided at the top of the borehole to support the complete rising column and electro-submersible pumpset assembly, and shall be complete with lifting eye bolts. The discharge head piece shall comprise a heavy duty sealing plate arranged for bolting to the borehole outer casing flange, and a 90^{o} discharge bend arranged for flanged connection to both rising column and horizontal surface pipework. Lifting eyes shall be provided in the sealing plate. A flange shall be provided and welded by the Contractor to the top of the borehole outer casing. The flange shall be suitably drilled to accommodate the discharge head piece sealing plate bolts. Holes shall be provided in the sealing plate to accommodate an air vent pipe, motor and control cables, water level dip

tubing, etc. and shall include adequate sealing arrangements to protect against borehole contamination.

A 25mm diameter screwed removable plug shall be provided over the dip tubing for water level measurement with electrical contact tape. A stainless steel air vent pipe shall be fitted to the discharge head sealing plate, terminating in an insect proof screen and arranged to prevent entry of rain or surface water.

304.8 VERTICAL TURBINE PUMPSETS

The pumps shall be of the vertical line shaft type. The discharge head shall be bolted onto a substantial steel bedplate or frame which shall in turn be bolted to the pump room floor. The discharge head shall have a flanged discharge. Replaceable seal rings shall be fitted on the impeller suction side if required to maintain pump hydraulic efficiency.

The pump shaft shall be of chromium stainless steel (13% chromium) minimum supported by bearings above and below each stage. Protection shall be given against the effects of entrained solids in the water being pumped intermediate bearings shall be lubricated by the liquid being pumped.

The line shaft shall be of the same material as the pump shaft, supplied in lengths not exceeding 3.0m, with screwed couplings. The line shaft bearings shall be spider type to locate the shaft in the tube and may also double up as line shaft tube couplers. Lubrication shall be provided to the bearings.

The pump suction shall be of at least equal diameter to the pump and shall be fitted with a suction strainer.

Means shall be provided of adjusting the pump shaft tension and position.

304.9 CHEMICAL METERING AND DOSING PUMPS

Chemical dosing shall be by means of electrically driven metering pumps unless otherwise particularly specified.

Metering pumps shall be of the plunger or progressive cavity type.

The effective range of the metering pumps shall be between zero and maximum with an overall repeatable accuracy within ±3%. Output shall be adjustable through a stepless variable stroke mechanism in the case of plunger pumps and variable speed motor or gearbox in the case of progressive cavity pumps.

The metering pumps shall be manually adjusted, and shall be calibrated to allow setting at the required dosage. Dose adjustment shall be possible whilst the units are in operation. Accurate dosing shall be maintained down to 10% of the maximum dosing rate.

The Contractor shall consider the liquid to be pumped and select the materials of construction so as to avoid corrosion. Mechanical glands are generally undesirable but where unavoidable, shall be to the approval of the Engineer.

For metering pumps of the plunger type the materials in contact with the liquid shall be polypropylene, stainless steel grade 316, UPVC or PTFE. Plungers shall be a high-alumina ceramic or stainless steel, grade 316.

Metering pumps shall be mounted on bed plates which shall be protected from gland drip. The pumps shall be driven by close coupled motors with reduction gears and have mechanisms housed in a totally enclosed oil bath.

At least one standby pump, fully connected into the chemical dosing system, shall be provided for each chemical, with local manual selection of duty and standby units. When pump duty change-over is effected the appropriate suction and delivery isolating valves shall be manually operated.

Stators and rotors for progressive cavity pumps shall be of materials selected having regard to the liquids being pumped.

The design and location of the metering pumps shall be such as to facilitate easy dismantling for the removal of any foreign matter.

Flushing facilities shall be provided for all chemical pipework at the inlet and outlet of each metering pump, together with drip trays to contain any spillage or leakage and piped to the nearest drain point. Provision shall be made for priming the systems to eliminate any air.

Each chemical dosing pump shall be provided with suitable isolating valves, an inter-connecting manifold system and, where necessary, loading valves. A calibrated glass container shall be provided connected into the suction manifold of each chemical pump so that its output can be checked.

Calibration curves shall be provided by the Contractor for all chemical dosing pumps.

304.10 PACKAGED BOOSTER SETS FOR COLD WATER SUPPLY

General

The set shall be a self-contained, fully automatic packaged unit which requires the minimum of maintenance to give maximum trouble-free operation. The systems consist of either 2, 3 or more individual pump and motor units which operate independently of one another and react immediately to fulfill system demand.

Each set incorporates diaphragm pressure vessels ready with a supply of water when demand arises. When draw-off exceeds the vessel’s storage capacity, the lead pump is automatically started by a pressure switch to cope with the demand. In the event of unusually high demand, or failure of the lead pump, the support pump (or pumps) will immediately start.

Pumps

Vertical multistage or horizontal end-suction centrifugal pumps.

Control panel

Sheet steel enclosure incorporating all electrical components necessary for an automatic operation of the pumpset. Interwired with motors and pressure switches, requiring only connections to main supply on site. In the event of malfunction of any pump a stand-by pump

will start automatically and panel will visually identify the faulty unit. The control panel in corporates a manual selector switch to allocate the role of lead pump in turns, to ensure an even distribution of work load.

Motors

Totally enclosed fan cooled (TEFC) direct-coupled motors, for 50 Hz supply, 380 voltages class F insulation.

Pressure vessel

Mild steel construction incorporating replaceable non-toxic butyl rubber diaphragm. Factory pre-charged to required pressure, eliminating the need for a compressor on site.

Valves

Each individual pump has an inlet and outlet isolating valve and a non-return valve on the discharge of each pump. This allows any pump to be removed from the set without the necessity to shutdown the system. An isolating valve is fitted on the pressure vessel line.

Pressure manifold

Each pump is controlled by its own individual pressure switch, factory set for system requirements and mounted with a common discharge pressure gauge on an aluminium manifold block. Receiving their signal through a high pressure PVC pipe which is connected to the discharge pipework.

Pipework

Pipework supplied in copper.

Baseframe

To be fabricated from 6 mm, flat mild steel plate, complete with panel support and holding-down lugs drilled and tapped to secure all pumpset components.

305. VALVES & PENSTOCKS

305.1 GENERAL REQUIREMENTS FOR VALVES

305.1.1 General

Small valves of ND less than or equal to 40 mm shall be provided with self locking handles or handwheels to prevent accidental operation.

Emergency isolation valves shall be gate, ball or plug valves.

Drain and vent valves shall be provided with a plug or blind on the discharge side.

Flangeless valves shall not be used as the first block valves against storage tank.

Unless otherwise specified, valves shall be epoxy coated internally and externally. The coating shall have a minimum thickness of 150 µm.

Threaded ends shall not be used for valve sizes larger than 50 mm ND.

All handwheels, headstock, foot brackets, guide bracket and thrust tubes shall be of cast iron.

Fixing nuts and bolts supplied by the manufacturer shall be as specified in the general requirements for fastners.

Valves shall be sized such that the velocity through the valve when fully open does not exceed 2.50 metres per second at the rated throughput. They shall have flanges to not less than BS.4504 NP.16 and shall be capable of withstanding the same test pressures as the pipeline on which they operate. All nuts and studs subject to vibration shall be fitted with spring washer or locking tabs.

305.1.2 Types and Operating Conditions

Valves shall be designed to meet the operational and environmental conditions specified for the types indicated in the specific valve schedule.

The closure rates of all valves shall be designed to prevent the effects of surge. Where necessary, valves with a varying closure rate shall be used.

Valve flanges or couplings shall be as specified in the valve schedule and match those specified for the pipework installation.

305.1.3 Identification

Each valve shall be identified by a unique reference as approved which shall identify the medium/plant controlled and be numbered in a logical sequence.

The reference shall be either engraved on a 3mm thick laminated white/black/white traffolyte disc or stamped on a 1.0mm (19g) thick brass disc. The discs shall be at least 35mm dia. with reference letters and numerals not less than 4mm and 8mm high respectively.

The discs shall be mounted on the hub of the handwheel or where this is impractical, they shall be attached to the valve stem by means of suitable brass 'S' hooks and/or jack chain through a hole at the top of the disc.

305.1.4 Access

All valves, spindles and handwheels shall be positioned to give good access for operational personnel. It shall be possible either to remove and replace or to recondition seats, gates or gland packings which shall be accessible without removal of the valve from the pipework or, in the case of power operated valves, without removal of the actuator from the valve.

Extension spindles shall be supplied wherever necessary to achieve the specified operating requirements.

305.1.5 Hand Operation

All handwheels shall be arranged to turn in a clockwise direction to close the valve or penstock, the direction of rotation for opening and closing being indicated on the handwheels.

The handwheels shall be coated with black plastic and incorporate facilities for padlocking in either the open or closed position.

Bituminous paints shall not be applied to any valve handwheel.

The operating gear of all valves and penstocks shall be such that they can be opened and closed by one man against an unbalanced head 15% in excess of the maximum specified service value and any gearing shall be such as to permit manual operation in a reasonable time and not exceed a required rim pull of 55kgf.

Power operated valves shall include equipment for manual operation by means of a handwheel or other suitable device which shall be interlocked with, and fixed to, the power unit.

Headstocks and valves of 125mm nominal bore and above shall be fitted with mechanical position indicators to show the amount which the valve is open or closed in relation to its full travel, i.e. 0.25, 0.50, 0.75, 1 etc.

305.2 VALVE MATERIALS

Valve bodies and other components shall be of corrosion resistant materials, compatible with the medium and of robust industrial design.

For water applications and where specified, valve bodies, discs and wedges shall be of cast iron, with facing rings, seating rings, wedge nut and other trim of corrosion resistant bronze or gun metal.

The valve stem, thrust washers, screws, nuts and other components exposed to the water shall be of a corrosion resistant grade of bronze or stainless steel.

For water works applications, wedge gate, metal seated valve materials shall be in accordance with BS 5163 Table 6A, fitted with a stuffing box and gland seal on the stem. Oil or grease shall not be used on any bearing or seal that may be in contact with the water being controlled.

The type and size of valve to be used to any particular location shall be as indicated on the contract drawings. Valve materials shall comply with the following minimum requirements.

ENVIRONMENT	BODY	TRIM**	REMARKS
Air	Carbon Steel or Bronze	410 SS Bronze	Blower discharge valves can be supplied to blower manufacturer standard.
Cl_2 Gas	Carbon Steel	410 SS	
Cl_2 Water	PVC	PVC	
Diesel Oil	Carbon Steel	410 SS	
Sewage	Ductile Iron Cast Iron PVC	Bronze* Bronze* PVC	Zinc free.
Potable Water	Bronze PVC Ductile Iron Cast Iron	Bronze* PVC Bronze* Bronze*	Less than 1000 mg/l total dissolved solids. Zinc free.

* Alternate acceptable materials for stem is aluminum bronze, or nickel aluminum bronze

** Trim material includes stem, body and closure seating surface, seat rings, bushings, springs, or any small parts in contact with service fluid.

305.3 SLUICE VALVES

All sluice valves, unless otherwise specified shall be of the rising spindle type, have wedge gates and be in accordance with the relevant clauses of BS 5150 and BS 5163.

Valves up to and including 300 mm ND shall be of the resilient seal or metal seal type. Valves larger than 300 mm ND shall have metal seals.

The valves shall be suitable for unbalanced head. A by-pass with gate valve forming an integral part of the valve shall be provided where recommended by the manufacturer for the pressures specified.

Where specified, sluice valves shall be fitted with easing screws and a clean-out box in the base.

Unless otherwise specified, each valve shall be provided with a suitable handwheel of adequate diameter for the duty required. Gearing shall be supplied where necessary, to ensure that the required operating force applied by hand to the rim of the wheel does not exceed 55 kgf.

Stem seals shall be of the stuffing box and gland type, arranged for easy replacement of packing and shall be accessible for maintenance without removal of the valve from service.

Extension spindles, headstocks and foot brackets shall be provided where required.

Where valves are required to be operated by tee keys spindle caps shall be fitted. The caps shall be drilled and each provided with nut and bolt for securing to the spindle, which shall likewise be drilled to accept the bolt. Each cap where fitted shall be supplied complete with operating tee key.

305.4 TELESCOPIC VALVES

All bellmouth telescopic valves shall have cast iron outer sleeves and bellmouths. The outer sleeves shall have machined labyrinth seals and the sliding tubes shall be manufactured from zinc free bronze.

A cast iron stirrup shall be affixed over the top of each bellmouth and these shall be connected to the rising screw thread by means of a stainless steel 'Rose' type coupling. To minimise fouling by rags etc. the valves shall not be fitted with outer guide rods.

305.5 NON-RETURN VALVES

Check valves shall comply with BS 5153.

All non-return valves shall be of a type that will operate without shock.

Valve bodies shall be of cast iron unless otherwise specified and shall be fitted with renewable type seatings.

Covers shall be provided to allow ample access for cleaning and service and shall be supplied complete with tapped bosses.

In the case of swing gate type valves the hinge pin shall be of stainless steel, mounted in zinc free bronze bushes and extended and fitted with external levers and counter balance weights, all protected by a screen guard.

Other types of valves will be considered. In every case the non return valve shall be selected with full consideration of the system characteristics, and shall avoid valve slam, and have low maintenance requirements.

Where specified, limit switches shall be provided to operate from the external lever. The screen guard being slotted to allow the guard to be removed without disturbing the switch cabling.

305.6 BUTTERFLY VALVES

Butterfly valves shall have a resilient disc seating and be designed for a positive leak-proof shut off at a minimum pressure of 16 bar. Non-wafer types are preferred.

Butterfly valves shall conform to BS 5155

The disc shall be in grey or ductile cast iron unless otherwise specified with a resilient seating ring in moulded rubber, or other material to the approval of the Engineer.

For valves of 350 mm ND and above, a suitably lubricated axial thrust bearing shall be fitted.

A stuffing box and gland shall be fitted on the operation shalft extension to seal the pressure side of the valve. The design shall be such as to facilitate packing replacement without removal of the valve from the pipeline.

A valve position indicator, to show the position of the disc, shall be provided on the valve operating gear.

Suitable stops shall be incorporated to prevent movement beyond the disc "fully open" and "fully closed" positions.

Valves for flow regulation shall be of all metal construction.

305.7 PLUG VALVES

Plug valves shall be of the wedge gate type, with cast bodies. The plug surface shall be coated or lubricated to ensure low torque operation with bubble tight shut-off and 'non-sticking' materials.

305.8 SLIDE VALVES

Unless otherwise specified, slide valves shall be of the lightweight pattern type with cast or ductile iron body, stainless steel slide and chromium steel outside rising screw spindle.

The valve body shall incorporate a transverse slide seal so arranged for easy replacement of the packing, which shall be accessible without removal of the valve from the pipeline.

Handwheels shall have smooth rims and of such diameter to enable one man to operate the valve. The direction of opening and closing shall be cast on the handwheel. The direction of closing shall be clockwise.

Valves of 125 mm, nominal bore and over shall be fitted with position indicators showing the amount which the valve is open or closed in relation to its full travel.

305.9 ISOLATING COCKS

For isolation of small bore pipework tappings for instrumentation equipment etc. and for individual component isolation, the cocks shall be stainless steel, quarter-turn, ball or plug valves with the operating handle arranged to indicate the open and closed positions. Where specified, means shall be provided for securing the valve body to a front panel or rear surface.

Where corporation cocks are specified, these shall be similar to the above isolating cocks but shall have a detachable key handle for fitting onto a squared operating shaft, the shaft end being marked to indicate the open and closed valve positions.

305.10 PENSTOCKS

305.10.1 General

All penstocks shall be designed and installed so that the maximum working pressure acts in a seating direction on the gate.
Both gate and frames shall be sufficiently rigid to withstand twice the maximum working pressure and any eccentric pressures created by the tightening of the anchor bolts during installation. All penstock frames shall have a spigot back.

The frame shall be designed to ensure that the gate is supported over not less than two thirds of its depth when the gate is fully raised.

Penstocks shall be of the rising spindle type unless otherwise specified, and the spindles shall be of adequate size to avoid buckling under load.

All spindle nuts shall be self aligning and their length shall be not less than twice the spindle diameter.

The top part of the penstock frames shall be sufficiently robust and substantial to prevent the frames bowing and if necessary, additional holding down bolts shall be fitted. The penstocks shall be fitted with matching wedges on doors and guides, the wedges shall be fitted with renewable seatings of zinc free bronze. Under no circumstances shall wedges be fitted to the bottom or lower sections of the penstock doors. The wedges shall be adjustable with stainless steel adjusting screws and shall be readily removable.

On rectangular penstocks the inverts shall be flush with renewable synthetic rubber seals on the bottom of the doors. The rubber shall be suitable for the application and of an approved type.

The doors shall have lifting eyes cast in, or eye bolts of sufficient size to permit the lifting of the door against seating pressure.

Where extended spindles installations require to be operated at elevated floor level, spindle guides or guide brackets shall be provided close to the floor level.

Where penstocks are required to be operated by the tee keys, spindles caps shall be fitted. The caps shall be drilled and each provided with nut and bolt for securing to the spindle which shall also be drilled. Where caps are fitted they shall each be supplied complete with operating tee key.

All penstock shall be provided with headstocks (except where the Handwheels can be mounted on the penstock frames). For penstocks of 300 mm ND. (square or circular) and above and for all motorized and actuator operated penstocks, unless otherwise stated, thrust tubes shall be provided between the penstocks frame and the headstock, in order to absorb the operating thrust in both directions. Thrust tubes shall incorporate all necessary fixing brackets and spindle quid plates.

Headstocks and foot brackets shall be provided for non-rising spindle penstocks where the latter are specifically called for. Guide brackets shall be provided where necessary. Non-rising spindles shall be fitted with thrust collars and arranged so as to transmit the thrust arising from operation of the penstock directly to the Penstocks frame. Where headstocks are required on non-rings spindles installations they shall incorporate a penstock position indicator.

Penstock shall be water-tight under the conditions of head and direction of flow as stated in the appropriate clause or schedule of the specifications and/or the contract drawings.

Penstock shall be water-tight under the conditions of head and direction of flow as stated in the appropriate clause or schedule of the specification and/or the contract drawings.

All bolt holes shall be drilled and spot faced.

Simple templates shall be supplied as soon as possible after approval of drawings to enable the Civil contractor to position the holes for holding down bolts for all penstocks over 1.0 m square.

305.10.2 Penstock Materials

Penstock doors, wedge support beams, frames, guides, frame extensions, headstocks and bridge pieces shall be cast iron, of minimum grade 220 to BS 1452. Doors and frames shall be fitted with renewable seatings of zinc free bronze.

Spindles shall be manufactured from stainless steel 431S29 (EN 57) or similar approved material.

305.10.3 Extension Spindles

Extension spindles shall be adequately sized to prevent buckling and shall be attached to the valve/penstock stem by a suitable adaptor incorporating two muff couplings, scarf lap jointed and pinned with at least two coupling joints included. Universal joints and waterproof sleeves shall be provided where specified. Extension spindles shall be manufactured from 080M40 (EN 8) steel.

Intermediate bearing support or guide brackets of cast iron, with slotted holes for site adjustment, shall be fitted to long shafts where necessary. Bearings shall be of PTFE or similar approved type.

305.10.4 Pedestals and Spindle Covers

Penstock and valve pedestals shall be of cast iron or heavy duty, welded, mild steel construction with a substantial base and fixing provision. The base and top of the pedestals shall be machined normal to the axis of the drive shaft.

Where necessary, support guide bushes shall be fitted as the base of the pedestal.

The pedestal height shall be such that the handwheel is approximately 1 metre above the operator's floor level.

Clear polycarbonate covers of an approved type shall be provided for all rising spindles to totally enclose them when in the fully raised position.

Each tube shall be clearly and permanently engraved to indicate the position of the penstock.

305.11 AIR VALVES

Air valves shall be of two types:

a) Single (small) orifice valves (SOV), for the discharge of air during the normal operation of the pipeline.
b) Double orifice valves (DOV), consisting of a large orifice and a small orifice. These shall permit the bulk discharge of air from the main during filling and air inflow when emptying in addition to the discharge of small quantities of air during normal operating conditions.

Air valves shall be supplied with an independent isolating butterfly valve (DOV) or cook (SOV) which permits the complete removal of the air valve from the main, without affecting the flow of water in the main.

The sizing of the air valve and isolating assembly shall be such that the pressure drop at design flow capacity does not exceed 0.5 bar.

Each air valve assembly shall be suitable for connection to a flange on the pipeline.

At the connection between the air valve and its isolating valve a BSP tapping shall be made suitable for fitting of a pressure gauge. All tappings shall be sealed by a brass plug and copper compression ring gasket.

Air valves shall operate automatically and be constructed so that the operating mechanism will not jam in either the open or closed positions.

305.12 HANDSTOPS (FOR SEWAGE ONLY)

Handstops shall have cast iron frames with galvanised mild steel doors.

Handstops shall be semi-circular or rectangular pattern according to the application or as specified.

Handstops shall be suitable for channel or wall mounting according to the installation requirements.

Handstops doors shall be provided with hand-slots to facilitate operation and a peg and chain shall be provided to hold the door in the open position. Pegs and chains shall be of stainless steel.

On deep channels or where specified, handstop doors shall be provided with lifting handles. Lifting handles shall be of identical material to the doors and guide/retaining brackets shall be provided.

All materials used in the manufacture of handstops shall conform with the requirements for Penstocks specified herein.

305.13 FLAP VALVES

Flap valves shall be of the following categories :

i) General purpose (excluding category (ii) applications).

ii) Seawater and other aggressive applications.

Flap valves shall be normally closed, by weight of the door only, and shall open under minimum flow conditions. They shall be capable of withstanding 1.5 times the specified maximum seating head.

Flap valves on tidal installations shall be capable of withstanding a minimum static head of 6 metres and a minimum surge head of 10 metres.`

Where flap valves are required for flange mounting, they shall be supplied with rubber gasket and the full number of holes to BS.4504 NP 16.

Fixing nuts and bolts shall be as specified in the fastners general requirements with the exception of seawater and other aggressive locations in which case they shall be of stainless steel only.

All flap valves shall be operated and painted in accordance with metal painting and protection requirements.

General purpose flap valves shall be of the double hung type and all valves of 600 mm opening and above shall be of the double door type.

All doors shall be provided with lifting rings and those of 600 mm opening and above shall be fitted with galvanised lifting chains.

305.14 PRESSURE RELIEF VALVES

Pressure relief valves shall protect pipes from accidental overpressure and surge.

It shall consist either of a low inertia valve guided by a flexible diaphragm ensuring a rapid response, and easily adjusted on site, or of a spring operating under compression, a fixed tapered discharge nozzle and a flat-disc mobile shutter.

These valves shall only open under a determined pressure slightly higher (almost 5%) than the maximum pressure for normal working conditions.

The body, sleeve, and gland shall be cast iron. The spring shall be stainless steel.

They shall be wafer type and occupy minimal space.

305.15 PRESSURE / FLOW CONTROL VALVES (REDUCING/REGULATING)

Control valves shall function efficiently of line pressure or flow without human intervention. They shall be hydraulically or electrically operated depending on the availability of a power source. The basic valve shall be heavy duty globe type to BS 5152 & 5160. It shall have no packing glands or stuffing boxes and shall be maintained with ease without removal from the pipeline.

The valve shall be coated internally and externally with epoxy 150 μm minimum thickness. The material of the valve and its elements shall be selected to suit the fluid in the line and the environmental factors such as abrasion, corrosion, pressure and temperature.

306. FASTENERS

306.1 GENRERAL REQUIREMENTS

All fastenings and accessories in contact with the process water shall be of stainless steel, cadmium plated mild steel or other corrosion resistant material subject to the approval of the Engineer. All bolts, nuts, screws, washers and other fixings for anchoring the plant to walls, floors, ceilings, etc. shall be of corrosion resistant material or shall have a protective surface treatment to the approval of the Engineer.

All bolts in inaccessible positions shall be secured by either self locking nuts, spring washers and nuts, or castle nuts with split pins. Fasteners associated with items requiring removal during routine maintenance shall be of stainless steel. All other items shall be sheradised or hot dip galvanised in matched condition.

306.2 BOLTS & NUTS

All bolts, nuts, studs and studbolts, including those required for installation at terminal points to existing equipment, shall be provided by the Contractor and shall have metric threads to BS 3643.

After tightening, the minimum engagement of the thread shall equal the thickness of the nut. The projection of the thread beyond the outer face of the nut shall not exceed one quarter of the outside diameter of the thread. In no circumstances shall galvanised or coated bolts be shortened by cutting.

Washers 3 mm thick shall be provided under all nuts and bolt heads.

All bolts, nuts, washers and anchor plates, except high tensile, for all ferrous parts shall be steel galvanised to BS.729 or sheradised to BS.4921 Class 1, primed and painted after assembly and tightening.

All bolts, studs, nuts, washers and anchor plates, for fastening aluminium alloy components shall be of stainless steel grade 316S16 to BS.970 and shall remain unpainted. PTFE washers shall be fitted beneath stainless steel washers for both bolthead and nut.

All bolts, nuts, studs and washers used in the construction of submersible pumps shall be stainless steel grade 316S16 to BS.970.

306.3 HOLDING-DOWN & ANCHORS BOLTS & NUTS

All holding-down and anchor bolts, nuts, washers and anchor plates for use externally or in internal areas which are subject to contact with sewage or effluent or in "wet" areas but above the top water level shall be of high tensile stainless steel grade 316S16 to BS.970.

All holding-down and anchor bolts, nuts, washers and anchor plates for use internally in areas not subject to contact with sewage or effluent shall be steel galvanised to **BS.729** or sheradised to **BS.4921** class 1 and all exposed surfaces shall be painted after assembly and tightening.

All holding-down or foundation bolts shall be supplied and shall be complete with hexagon nuts and washers. Bolts of steel round bar formed into a loop at one end are not acceptable.

306.4 RIVETS

Rivets are to conform to the appropriate British Standard and for general use pan heads are preferred. Rivets on bearing surfaces are to be flat countersunk, driven flush. Whenever practicable, riveting is to be done by hydraulic tools and the rivets must completely fill the holes when closed. If loose, or if the heads are badly formed, cracked, eccentric to the shank or do not bear truly on the plate or bar, rivets, are to be cut out and replaced. All surfaces to be riveted must be in close contact throughout.

307. PLUMBING AND DRAINAGE

307.1 GENERAL

307.1.1 Scope of works

Work under this Section shall encompass the supply and installation of the following:

1. Sanitary fixtures including water heaters, valves and fittings, booster sets
2. Water distribution and supply system
3. Waste water drainage system from sanitary installations
4. Storm water drainage system.

Sanitary fixtures shall be complete and include labor, supply and installation of all pipes and their supports, connections to existing pipes or to sanitary fixtures, valves, accessories, as well as fixing, excavation and backfilling works required for the piercing and repair of walls, slabs and ceilings, and this, according to the drawings and the specifications of this Section.

307.1.2 Non restrictive list of works provided for in this Section

- Cold water distribution to sanitary installations and intakes
- Hot water distribution to sanitary installations
- Drainage of waste water and storm water to sewers or septic tanks
- Execution of primary ventilations
- Supply and installation of all floor drains
- Sanitary fixtures
- Waste water lifting systems
- Sinks
- Openings in partition walls and masonry
- Plugging up openings left in concrete surfaces after pipelaying
- Equipotential connections
- Branching of all fixtures
- Operation tests.

307.1.3 Contract documents

Nota: The list of texts mentioned hereunder is not restrictive. Works should be consistent with all texts in force at the time of their execution.

Plumbing

1) Unified Technical Documents (DTU)

1.1	Sanitary plumbing for dwellings (DTU P40-201)	
	Tender document	October 1959
	Chapter IV of tender document	November 1981
	Supplement N° 1: Installation of inserts in floors and walls	July/August 1969
	Supplement N° 4: Steel pipes for water distribution inside buildings	
	Particular specifications document and Memento thereto	January/February 1977

	Supplement N° 5 modifying supplement N° 4: Steel pipes for water distribution inside buildings	December 1979
	Erratum	April 1980
1.2	Cast iron pipes for waste water, storm water and sewage drainage (DTU P41-220)	
	Technical Specifications Document	July 1984
1.3	Calculation rules for sanitary plumbing installations and storm water drainage installations (DTU P40-202)	October 1988

Unplasticized P.V.C pipes

1.4	Storm water drainage (DTU P41-212)	
	Tender document	November 1981
1.5	Waste water and sewage drainage (DTU P41-213)	
	Tender document	November 1981

1.6 CIBSE Guide B8: Sanitation and waste disposal 1972

1.7 Code of practice CP3; Engineering and utility services

1.8 Code of practice CP304; 1968 Sanitary pipework above ground

1.9 Code of practice CP301; 1971 Building drainage

1.10 Code of practice CP305; Sanitary appliances

1.11 Code of practice CP308; 1974 Drainage of roofs and paved areas

1.12 The uniform plumbing code for housing

1.13 Plumbing manual

1.14 National plumbing code

2) Standards

French standards; NF class:
- A pipes
- D fixtures
- E valves and fittings - connections
- P sanitary plumbing
- T PVC

Simple faucet of sanitary fixture - Vocabulary	NF D 18-001
Sanitary valves and fittings - Simple faucets and washer type mixers - General technical specifications	NF D 18-201
Mechanical washerless mixers - General technical specifications	NF D 18-202
Valves and fittings - globe valves used as isolating valves - terminology specific to valves and fittings installed in buildings	NF E 29-064
Hot or cold water distribution (terminology)	NF P 41-101
Waste water drainage (terminology)	NF P 41-102

Code of the minimum conditions for the execution of plumbing works

and urban sanitary installations	NF P 41-201
Globe valves used as isolating valves - General technical specifications	NF P 43-001
Water pressure reducers - General specifications	NF P 43-006
Globe valves used as intake valves - General technical specifications	NF P 43-015

British standards; BS class

Cast Iron Spigot and Socket Drain Pipes and Fittings, Part 1: Pipes, Bends, Branches and Access Fittings.	B.S.	437
Concrete Cylindrical Pipes and Fittings, Including Manholes, Inspection Chambers and Street Gullies. Part 2: Metric Units	B.S.	556
Schedule of Cast Iron Drain Fittings, Spigot and Socket Type, for use with Drain Pipes to B.S. 437	B.S.	1130
Steel Tubes and Tubulars Suitable for screwing to B.S. 21 Pipe Threads	B.S.	1387
Asbestos-Cement Pipes, Joints and Fittings for Sewerage and Drainage.	B.S.	3656
Unplasticized P.V.C. Soil and Ventilating Pipe, Fittings and Accessories.	B.S.	4514
Prestressed Concrete Pipes for Drainage and Sewerage.	B.S.	5178
Specification for Unplasticized P.V.C. Pipe and Fittings for Gravity Sewers.	B.S.	5481
Cast manhole covers, graings, gullys, etc	B.S.	497

307.1.4 Openings in concrete surfaces and repair works

The Contractor shall bear the costs of labor and supply of materials required for the execution of openings and reinstatement of masonry and/or concrete works, as well as for preliminary or complementary works pertaining to sanitary installations, regardless of the difficulty of such works. No piercing in load-bearing structures (columns, beams, ...) shall be allowed unless so approved by the Engineer. Openings and storm water drainage system shall be carried out in accordance with Sections: waterproofing of New Works and Concrete Works.

307.1.5 Cleaning and protection

The Contractor shall be responsible for the protection of all sanitary fixtures from any damage and until the taking over of works.

All openings in the slab shall be sealed and protected. Floor drains shall be covered. Pipes free ends shall be protected against the intrusion of foreign bodies. The use of new sanitary fixtures throughout the works shall not be allowed.

Openings in roofs for storm water drainage shall be consistent with Waterproofing of New Works and Concrete Works. On completion, all fixtures and accessories shall be cleaned and polished.

Prior to taking over, the Contractor shall clean all the installation and purge all piping systems in order to ensure that they are free of wastes. In case pipes are plugged, the Contractor shall clean them and put them into service at his own expense.

307.2 PIPES AND FITTINGS

307.2.1 Application

Water pipes external to the buildings (i.e. undergound) shall be galvanized steel, threaded, in accordance with DIN 2440, medium duty or equivalent. (BS 1387).

Hot, cold and potable water pipes inside buildings shall be copper solder type to BS 2871 table X exposed and painted to Engineer requirement.

Waste water drainage pipes inside toilets shall be PVC according to DIN 19531 or UPVC to BS 4514.

Waste water drainage pipes underground shall be UPVC according to BS 4660 or equivalent.

Storm water drainage pipes inside shafts and between external manholes shall be of PVC according to DIN 19534, heavy duty or equivalent.

Storm water drainage pipes built-in walls shall be of PVC according to DIN 19531, heavy duty or equivalent.

Storm water drainage pipes between external manholes shall be of PVC according to DIN 19534, heavy duty or equivalent.

307.2.2 Galvanized steel pipes

307.2.2.1 Jointing of pipes

Pipes shall be gas threaded, WHITWORTH system; it shall bear at least 2 times the maximum pressure. Pipe threading shall be done with a screwing-stock without a ratchet, and shall stretch over 18 to 20 mm approximately.

No bending of pipes shall be permitted. Jointing by welding shall be prohibited. Jointing and connection works shall only be carried out by means of tees, elbows, couplings, hammer lug unions and flanges.

The seal of joints shall be ensured by a hemp tow coated with ceruse or linseed oil or an equivalent tape. Couplings shall have protruding rims to prevent ovalization due to vice tightening. Joints (elbows, tees, coupling, nipples, hammer lug unions, etc ...) shall be of a known trademark: A.F.L or G.F. or the like. Joints shall be reduced in factory and not by means of reducing couplings.

Pipes shall be connected to the equipment or valves by means of hammer lug unions. Hammer lug unions or flanges shall be mounted on the pipes in judiciously chosen locations so as to facilitate the assembling and dismantling of a section of the distribution network.

307.2.2.2 Pipes fixing

Exposed pipes laid under a ceiling, on roofs and inside shafts shall be fixed on iron, U stay-rods and struts by means of rigid fixing collars.

U struts shall be clamped to the ceiling with two rods threaded at both ends. The upper end shall be inserted in a “read head” type female socket embedded in the slab. The lower end of the rod shall support the strut by means of a nut.

The number of supports shall be sufficient to avoid deflection, shocks, expansion, etc ...

Spacing between supports and the diameter of bearing rods depends on the pipe diameter.

Pipes	1/2″, 3/4″, 1″	1 1/4″, 1 1/2″, 2″	2 1/2″, 3″, 4″
Spacing	1.5 m	2.25 m	3 m
Diameter of the rod	12 mm	12 mm	12 mm

307.2.2.3 Sleeves

Walls and slabs penetrations shall be through steel sleeves embedded in the cement, allowing the free expansion of pipes.

The sleeves diameters shall be determined with due regard to the pipes diameters so as to insert an isolating plastic between the steel sleeve and the metal pipe whenever used.

Sleeves shall receive an inside and outside rustproof protection and shall be built-in in masonry prior to pipe installation.

Measures shall be taken to avoid dust projection and noise transmission through the sleeves from one room to the other.

307.2.2.4 Finishing and protection

Pipes embedded in masonry shall receive a cathodic protection by means of 3M plastic adhesive tape or Denso tapes or any approved equivalent. The tape shall be regularly applied to cover the entire pipe.

Threaded pipes shall be protected with an oil or graphite coating or any other equivalent to ensure total watertightness. Exposed water pipes shall be isolated with a 25 mm thick fibreglass.

Protruding pipes and their supports shall be coated with an anti-corrosion paint of an approved colour.

307.2.2.5 PVC drainage pipes

All material, pipes and fittings, various connections, tees, elbows, reducing couplings, O rings shall be of a European trademark.

307.2.2.6 Thickness of pipes

Thickness of pipes shall be to DIN 19531 or DIN 19534 or equivalent as follows:

1- Standard pipes to DIN 19531:

Diameter 1 1/2″	thickness 1.8 mm
Diameter 2″	thickness 1.8 mm
Diameter 3″	thickness 1.8 mm
Diameter 4″	thickness 2.2 mm

2- Heavy duty pipes to DIN 19534:

Diameter	4″	thickness 3 mm
Diameter	5″	thickness 3 mm
Diameter	6″	thickness 4.5 mm

307.2.2.7 Mounting, fixing and finishing works

Heavy duty pipes shall be jointed with O rings, and standard pipes with glued joints to the satisfaction of the manufacturer.

Pipes shall be cut with a saw. Male ends of sawn pipes shall be trimmed and beveled prior to jointing. Technical specifications of the manufacturer shall be observed. Inaccessible jointings shall be glued.

Storm water pipes crossing false columns or embedded in concrete shall be covered, prior to concrete placing, with corrugated cardboard which shall be well compacted around the pipe up to a uniform thickness of 2.5 cm minimum.

Crossing of partition walls load-bearing, walls, floors shall be through a sleeve having a diameter roughly larger than that of the pipe.

Exposed pipes shall be fixed by means of U rods as specified for galvanized pipes.

307.2.3 Pipe laying

Pipelaying shall be to D.T.U. 60.1.

Main lines shall be laid exposed at low-level or in false ceilings wherever existing. Branchings connected to fixtures shall be carried out exposed unless otherwise instructed by the Engineer.

Pipes and fittings shall have as much as possible vertical and horizontal routes and allow the free flow of water from and to all installations and fixtures.

Horizontal pipes shall have the following slopes, unless otherwise provided for by the Engineer:

Water supply pipes	0.5 to 1%
Waste water drainage pipes inside toilets	2%
Waste water and stormwater drainage pipes, buried or laid inside false ceilings	1%

Cleanouts, even where not specifically called for shall be installed at each change of direction in storm and waste water pipes.

Prior to jointing pipes, they shall be thoroughly cleaned so as to ensure the total absence of any foreign body.

Pipes having different diameters shall be jointed by means of eccentric reducers.

Except for pipes crossing masonry, all protruding pipes shall be kept 3 cm clear from vertical walls, slabs, ceilings and any other pipelines. However, the distance between such pipes and floors shall be 5 cm. Protruding or built-in pipes shall be accessible all along their route in order to facilitate inspection, maintenance or eventual modifications.

Automatic drain traps shall be mounted at high points of pressure water pipes.

To allow free expansion, the distribution network shall be so arranged as to move occurring expansions towards compensating devices. The latter shall be mounted by the Contractor although not specified on the drawings.

307.2.4 Pipe insulation

307.2.4.1 General requirements

- Insulation shall be carried out neatly and to a high standard by skilled workers, experienced in the trade.

- The thermal insulation shall be non-corrosive to the metal, water repellant and fire retardant.

- All metal surfaces shall be thoroughly cleaned and treated with approved corrosion inhibitor before applying insulation. Inhibitor coating would not be required for galvaniazed surfaces.

- Strainers, valves (size 80 mm and above) and other fittings which require opening for maintenance/repairs shall be provided with insulated boxes.

- All openings in roof slabs and walls for passing pipes should be suitably weather proofed. Metal sleeves should be provided where pipes pass through masonary walls or partitions. All openings in roof, ceiling or walls made for the purpose installation shall be sealed to prevent ingress of rodents, insects, dust, moisture and water. Opening in equipment casings shall be sealed likewise.

- All pipe insulation shall be covered with cotton canvas/fiberglass cloth and vapour sealed. The cloth shall be soaked in approved weather proofing compound and wrapped careffuly to provide a smooth surface, free from wrinkles and gaps. There should be at least 50 mm overlap at transverse and longitudinal cloth joints. Second coat of vapour seal shall be applied after drying of the first coat. This vapour barrier finish shall be carried over the load bearing inserts at location of supports or hangers without discontinuity or punctures.

- The vapour seal material shall be fire resistant, non-toxic, weather resistant and anti-fungus quality. Bitumen based products shall not be used.

307.2.4.2 Hot water pipe insulation

- All hot water pipes are to be insulated with rigid fibreglass sections of density not less than 96 kg/m^3, thickness of insulation shall be 25 mm. minimum, or 19 mm thick foam rubber.

  Higher thickness of insulation shall be used, for large pipes and headers, if specified.

  Performed sections of other insulation materials (except expanded polystyrene) may be specified subject to the considerations of safety, hygiene and finish and subject to the prior approval of Engineer.

- Threated hardwood rings or approved plastic inserts shall be provided between the pipes and supports.

- Aluminum cladding shall be provided for mechanical protection over insulated and vapour sealed exposed hot water pipes in plant rooms upto a height of 2.2 m from floor level and in the boiler room.

307.3 WATER SUPPLY VALVES AND FITTINGS

307.3.1 General

All necessary valves and fittings, required for the installation of sanitary fixtures according to the drawings and the following specifications, shall be supplied and installed.

Gate valves shall be used to isolate and cut off water from main lines or branchings. Washouts shall be installed at the foot of rising columns and at the low spots of water systems. They shall be ½" in diameter and have a male connection for flexible pipes or as shown on the drawings.

Threaded couplings valves shall be connected to the pipes and fittings by means of hammer lug unions.

Flanged valves shall be connected to the pipes and fittings by means of glands, joints and bolts; flanges and glands shall be drilled according to the standards of the country of origin.

Valves shall be installed to allow easy access and dismantling.

Working and tests pressures shall equal respectively 6 and 12 bars.

307.3.2 Check valves

Check valves shall be either of the swing or lift type. They shall be installed on horizontal or upward vertical pipes.

For diameters ≤ 2 ½″, the valves shall be bronze and fitted with tapped couplings. For diameters > 2 ½″, the valves shall be cast iron, fitted with flanges. Sealing surfaces and the hinge pin shall be of stainless steel.

307.3.3 Float valves

Float valves shall be of the swing handle type. The body and small handles shall be made of bronze, and the long handle of stainless steel.

The valve shall be made of durable and resistant plastic material or of rubber.

307.3.4 Automatic drain traps

They shall be fitted with a float that operates the air release mechanism.

The trap shall be supplied along with a stop valve, installed downstream of the trap and allowing the dismantling of the latter without need to empty the installation.

307.3.5 Surge suppression devices

Surge suppression devices shall be of stainless steel with an elastomer membrane for a working pressure of 10 bars with a ½″ pipe connection. They shall be of JOSAM trademark or any equivalent.

307.3.6 Slide valve

Slide valves ≤ 2″ in diameter shall be made entirely of bronze, with iron tubes thread, and fitted with an iron handwheel.

307.3.7 Gate Valve

Gate valves ≥ 2½″ in diameter shall have an iron body, fitted with glands and operated by an outside screw and yoke and a handwheel.

307.3.8 Globe Valve

Globe valves ≤ 2″ in diameter shall be made of bronze, with iron tubes thread and fitted with a replaceable disc of approved type.
Globe valves ≥ 2½″ in diameter shall have an iron body, fitted with glands and a replaceable bronze thrust plate of approved type.

307.4 DRAINAGE ACCESSORIES

307.4.1 Floor drains

Floor drains shall be PVC and of an approved European trademark.

Each floor drain shall have three 2″ inlets, and one 3″ horizontal outlet. It shall be equipped with a chromium bronze strainer screwed to the frame. The strainer's dimensions and orientation shall comply with tiling constraints.

307.4.2 Balcony drains

Balcony drains shall be made of PVC and of an approved European trademark. They shall be fitted with a stainless steel plated strainer and have a horizontal outlet for connection beneath the tiles.

307.4.3 Roof drains

Roof drains are installed to discharge storm water of unused roofs. They shall be PVC made and of an approved European trademark.

Each drain shall comprise a drainage funnel and a strainer screwed to the top of the funnel embedded in the sealing material.

307.4.4 PVC inspection holes

PVC right-angled crosses, 4 inches in diameter, having 3 inlets and one outlet shall be used as inspection holes inside toilets.

One of the inlets shall be fitted with a completely tight chromium bronze cover, screwed to the frame and intended for cleaning.

307.4.5 Floor cleanouts

They shall consist of PVC 45° bend or a T or F connection with a completely tight door screwed to the frame.

307.4.6 On-line cleanouts

They shall all be of the same trademark as the pipe and provided with a bolt down door. They shall be installed at every 90° deviation.

307.4.7 Concrete manholes

Concrete manholes shall be constructed outside the building to collect waste and storm waters into two distinct networks. They shall be constructed at each change of direction or diameter of the drainage pipe and to the details shown on the drawings.

Storm water manholes shall be fitted with a cast iron grating fixed on a cast iron frame.

Waste water manholes shall be equipped with a cast iron watertight cover fixed on a cast iron frame.

The lower part of the manhole shall consist of a concrete slab proportioned at 350 kg of cement per 1 m^3 of gravel and 0.5 m^3 of sand.

It shall be rendered with a cement mortar (600 kg) to have a perfectly smooth surface showing no asperity likely to retain impurities.

The concrete walls of the manholes shall be 0.20 cm thick and made of precast elements or cast-in-place.

The outgoing pipes bottom shall line up the lowest level of the waste water manhole. The base slab of storm water manholes shall be, on the contrary, 5 cm deeper than the outgoing pipes level in order to retain leaves and waste.

The dimensions of the manhole vary with the depth as indicated hereinafter:

Depth	**Dimensions**
Down to 40 cm	40 × 40 cm
Down to 120 cm	60 × 60 cm
From 120 to 180 cm	100 × 100 cm
More than 180 cm	120 × 120 cm

307.4.8 Main ventilation column

The top of the main ventilation column shall be fitted with PVC ventilation hood mounted on roofs and kept as much as possible away from visited places. They shall be equipped with an insect proof screen.

307.5 SANITARY FIXTURES

307.5.1 General

All sanitary fixtures shall be submitted to the Engineer for approval and prior to ordering.

All sanitary fixtures shall be new, of the colour specified by the Engineer, of first grade quality and flawless. All visible accessories such as flushes, fittings, escutcheons, pipes and fixing nuts shall be made of shiny chromium - plated brass, and shall have smooth lines with no protruding parts.

All sanitary fixtures shall be set level and true allowing to make right angled connections with adjacent walls. Openings and holes shall be plugged carefully as to comply with the finishing material of walls and floor.

All visible chromium plated fittings, as well as stainless steel connections and accessories shall receive, directly after installation, a thick coat of protective petroleum gelatinous material.

Brackets, supports and embedded ironworks shall be coated in situ with an anti corrosion paint.

307.5.2 Washbasins

Washbasins shall be made of glazed porcelain and shall be complete with chromium-plated taps and washer type mixer, brackets, an angle valve, U-bend pipes, supply and waste piping, a soapdish, a towel rail, a mirror, a shelf and all other accessories.

Each branching for hot or cold shall not be less than ½".

307.5.3 Water closets (seats)

Water closets shall be fitted with a 13 liters capacity flushing vessel and ½″ angle valve. No W.C. branching shall be less than ″.

Each branching for hot or cold shall not be less than ½".

307.5.4 Sinks

Sinks shall be of stainless steel and shall incorporate the worktop. They shall be equipped with three chromium plated taps (hot, cold and drinking water), a strainer, a polypropylene trap, stop valves, supply and waste piping, fixing devices and all other accessories.

Each branching for hot or cold shall not be less than ½".

307.5.5 Shower cabinet

Shower cabinets shall be of the built-in or surface mounted shower tray type measurements of $90 \times 90 \times 28$ cm^3. They shall include a shower head with variable direction, hot and cold water taps, a washer type mixer, connection and waste pipes and all other accessories.

Each branching for hot or cold shall not be less than ½".

307.5.6 Urinals

Urinals shall be glazed porcelain wall mounted $43 \times 24 \times 47$ cm^3 with pressurized flushing, separated each 60 cm by adequate partition walls.

They shall be complete with a push-button faucet, chromium plated trap, supply and waste piping as well as all accessories.

Each branching for hot or cold shall not be less than ½".

307.6 WASTE WATER DRAINAGE SYSTEM

307.6.1 General

The waste water drainage system shall be complete and consistent with the drawings and the specifications below. The system shall comprise manifolds of sanitary fixtures, drops, mains, ventilation pipes, inspection holes, manholes, the installation of sump pumps and their control mechanisms, accessories, suspensions, supports, fixings and all other required accessories necessary for the good functioning of the installations.

307.6.2 Piping

Pipes used for this system shall be consistent with the specifications of Waste water drainage pipes.

Unless otherwise indicated, the diameters of drainage pipes shall be as follows:

W.C.	4″
Sink, wash basin	2½″

Connections between drops and horizontal manifolds shall be through long radius elbows. Cleanouts shall be mounted at the foot of every drop, every change of direction, at the end of every branch as indicated on the drawings or required by the Engineer. They shall not be more than 15 m apart for 4″ horizontal manifolds, and 30 m maximum apart for those of a

diameter exceeding 4″. Manifolds shall have a gradient of 1% in the flow direction unless otherwise specified.

307.7 GULLY TRAPS

Gully traps shall be of concrete or asbestos-cement, as shown on the Drawings. All internal surfaces of the gully traps shall be smooth and all edges rounded. The inside of concrete traps shall be plastered with cement mortar trowelled to a glossy surface. The trap seal shall be 5 cm minimum. The trap shall be placed on a concrete bedding at least 10 cm thick and shall be surrounded by concrete.

307.8 RAINWATER DISPOSAL

The rainwater disposal system shall be in accordance with the Drawings and/or as required in the Particular Specification.

Unless otherwise specified, the minimum diameter of leaders shall be 100 mm, except that for draining very small areas the Engineer may permit the installation of 75 mm dia. leaders. In any case the outlet of the leader shall be a 100 mm dia. bend. All leaders shall be installed in a straight line from the gutter to the outlet. If bends in a leader cannot be avoided, appropriate openings, easily accessible for cleaning, shall be provided on the bends. The top inlets of leaders shall be protected by stainless steel or galvanized wire strainers. The free outlets of leaders, where not connected to manholes of the storm water pipe system, shall terminate in 45° of 60° bends. The drain water shall drop onto a precast concrete dish diverting the water away from the foundations of the buildings.

307.9 SEPTIC TANK

307.9.1 General

Septic tanks shall be provided for small communities, and only whenever it is not possible to connect the sewerage system to a wastewater treatment facility. The tank shall be constructed in accordance with the drawings and/or as required in the Particular Specifications.

The septic tank shall achieve liquid-solid separation and shall provide digestion and storage of the settled organic solids.

307.9.2 Detailed Specifications

Septic tanks shall be designed and constructed in accordance with the following criteria:

a) A minimum hydraulic retention time of one day for the end of the design period average daily flow.

b) A minimum of one year production of sludge and scum storage capacity.

c) Design flow of 120 liter/capita/day shall be used in calculating the tank capacity.

d) Overall tank length shall be 2 to 3 times the tank width.

e) Water depth shall be between 1.2 m to 1.7 m. Minimum clearance between tank roof and liquid level shall be 0.3 m.

The septic tank is divided into two compartments with the first compartment having twice the volume of the second compartment. This arrangement shall ensure that the hydraulic load and the turbulence created by the incoming wastewater is absorbed in the first compartment. The second compartment shall achieve settlement for the low density solids since it receives the hydraulic load at a lower rate than does the first compartment.

The incoming wastewater shall enter the first compartment via a 200 mm ductile iron tee. The tee shall be designed and installed so as to dissipate the energy of the incoming water, to minimize turbulence, and to prevent short circuiting. The vertical leg of the inlet tee shall extend below the liquid surface to the specified level in accordance with the drawings.

The outlet of the first and second compartment shall be constructed in a manner so as to retain the sludge and scum formed in both compartments. The outlet of the first compartment is comprised of two (2) 200 mm dia elbows equally spaced along the width of the intercompartmental wall. The outlet of the second compartment is comprised of a one(1) 200 mm dia tee. The outlets shall have the submergence and height above the liquid level in accordance with the drawings.

A gas deflection baffle shall be provided underneath the outlets to prevent the entrance of gas disturbed sludge in the rising leg of the outlets.

307.9.3 Venting Provisions

The septic tank shall be vented to allow for the escape of accumulated methane, hydrogen sulfide, and other gases produced from digestion of the settled solids.

A 200 mm vent pipe shall be constructed on top of the second compartment and shall extend 3m above the finished grade level. Gases formed in the first compartment shall be vented to the second compartment via two 100 mm dia openings in the intercompartmental wall. The two openings shall be located above the scum level in accordance with the drawings.

307.9.4 Access Manholes

Two manholes with cast iron covers shall be provided over the inlet and final outlet pipes. The manholes shall provide access and means to inspect the inside of both compartments. The manholes shall also be used whenever tank desludging is required. The manhole covers shall be fitted with gaskets to provide a weather proof seal. Two each 300 mm inspection pipes with removable covers shall be provided on top of the first compartment outlets pipes.

307.9.5 Structure of the septic tank

External walls of the precast or cast-in-place septic tank shall have a nominal thickness of 25cm; the partition walls between the tank’s compartments shall be 20 cm thick.

Each vertical wall shall be reinforced with two layers of high yield steel bars installed at the rate of 6 HA 14/m in both directions and on both sides. Bars shall be kept 4 cm clear from the formwork.

The base slab shall be connected to the upper slab by bending the bars in such a way as to ensure a 50 cm penetration into each of the slabs.

The upper slab shall be 25 cm thick for tanks 2 m wide.

The base slab of the tanks shall be 25 cm thick, and shall extend a distance of 15 cm, from both sides of the tank walls. It shall be laid on a 10 cm thick concrete blinding layer.

Following are the concrete mix design:

– Base slab, upper slab and vertical walls: 350 kg of supersulphated portland cement (CLK) for 400 liters of sand and 800 liters of fine gravels

Generally, hydrostatic tests shall be conducted on the pipes before they are connected to fixtures.

In no case shall the pressure tests of pipes, equipment, etc ... exceed the working pressure of such pipes, equipment, etc ... Prior to and upon completion of tests, all equipment, piping, strainers, etc ... shall be thoroughly cleaned and put into working order.

307.10 MISCELLANEOUS DEVICES

307.10.1 Domestic water reservoirs

Domestic water reservoirs shall be made of 4 mm thick polyethylene and suitable for drinking water storage.

The reservoir shall resist ultra violet radiations and support without showing any deflection whatsoever, a temperature equal to 70° C.

It shall be manufactured to FDA21 - CFR 177, 1526 or equivalent.

The capacity shall be indicated on the drawing (> 1000 liters). All necessary accessories for the good functioning of the reservoirs shall be provided.

307.10.2 Electric water heater

Electric water heaters shall be installed according to the drawings. They shall be of the wall mounted or under sink installed type. They shall have an enamelled tank and shall be fitted with an automatic drain trap, a safety valve and all necessary accessories (heating element, adjustable thermostat, thermal insulation, ...).

Water heater shall be capable of heating the water capacity mentioned on the drawings to 80°C.

307.11 PAINTS

Work under this Section include the following:

Prior to any insulation metal pipes and reservoirs shall be wire brushed and coated with a bituminous or rustproof paint. Exposed covers and covered equipment shall receive a primer and a finish paint.

Reservoirs shall be lined and coated with 2 layers of rustproof paint.

307.12 TESTING

Each test report shall contain the following minimum information:

- The nature, hour and place of the tests
- The adopted procedure
- Means, material and labor
- The results.

Watertightness and mechanical strength tests of supply pipes and their accessories shall be carried out prior to painting.

Before conducting any test, a thorough cleaning of the whole installation shall be carried out.

Sections of pipes shall be isolated in order to carry out tests thereon under the required pressure.

A hydrostatic test shall be carried out at a pressure of 9 bars that is 1.5 times the maximum working pressure in order to check out:

- The valves mechanical strength
- The watertightness of pipes and their accessories.

The test pressure shall be maintained for 24 hours. Should the pressure tests be unsatisfactory, the Contractor shall search for and make good all defects causing leakages. After repairs, the installation shall be retested until it satisfactorily passes the test. Upon completion of the watertightness test, another test under the maximum working pressure shall be conducted. The pressure shall be maintained unchanged for 12 hours.

The watertightness test of waste water drainage pipes shall be conducted using a smoke cartridge that produces a smoke volume superior to that of the tested pipes.

Ventholes shall not be plugged before smoke has come out through their whole sections. No joint shall show any smoke leak.

In the case of unavailability of appropriate material required for tests using smoke, hydrostatic tests under a 0.2 kg/cm^2 test pressure shall be carried out after having closed all the outlets and have purged all pipes.

All waste and storm water drainage system shall be subjected to a pressure test of 5 meters of water. The hydrostatic pressure of the test shall be maintained for two hours without the system showing any leak or drop in pressure.