215 - ROOFING

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215 ROOFING

215.1 GENERAL

The provisions of this Division shall apply to roofing with sheets of corrugated material, including the following:

- Asbestos-cement
- Galvanized steel
- Zinc
- Extruded rigid P.V.C.
- Translucent glass fibre reinforced polyester.

Roofing with other materials, if required, will be dealt with in the Particular Specification.

215.2 STANDARDS AND CODES

The current British Standards and Codes of Practice, detailed below, shall, by reference, form a part of this Specification:

B.S. 690	Asbestos-Cement Slates and Sheets. Parts 1 to 6
B.S. 2717	Glossary of Terms, Applicable to Roof Coverings
B.S. 4154	Corrugated Plastic Translucent Sheets Made from Thermosetting Polyester Resins (Glass Fibre Reinforced)
B.S. 4203	Extruded Rigid P.V.C. Corrugated Sheeting
B.S. 5247	Code of Practice for Sheet Roof and Wall Coverings. Part 14: Corrugated Asbestos-Cement
C.P. 143	Sheet Roof and Wall Coverings. Part 5: Zinc. Part 10: Galvanized Corrugated Steel.

In case of discrepancy or contradiction, the requirements of this Specification shall prevail over any Standard or Code of Practice.

215.3 MATERIALS

All the sheets and fittings for roofing shall be new, sound, without defects and shall meet all requirements of the relevant Standards and/or of the Particular Specification. Cracked, chipped, bent or otherwise defective or deformed sheets shall be rejected.

Where steel or wrought iron is to be galvanised, it shall be carried out by the hot-dip process and shall conform in all respects with BS.729.

Attention shall be paid to the detail of members in accordance with BS.4479. Adequate provision for filling, venting and draining shall be made for assemblies fabricated from hollow section. Vent holes shall be suitable plugged after galvanising.

All surface defects in the steel including cracks, surface laminations, laps and folds shall be removed in accordance with BS.4360. All drilling, cutting, welding, forming and final fabrications of unit members and assemblies shall be completed before the structures are galvanised. The surface of the steelworks to be galvanised shall be free from welding

slag, paint, oil, grease, and similar contaminants. The articles shall be pickled in dilute sulfuric or hydrochloric acid, followed by rinsing in water and picking in phosphoric acid. They shall be thoroughly washed, stoved and dipped in molten zinc and brushed, so that the whole of the metal shall be evenly covered and the additional weight thereof after dipping shall not be less than 610 grammes per square metre of surface galvanised, except in the case of tubes to BS.1387 and 788 when it shall be 460 grammes per square metre.

On removal from the galvanising bath the resultant coating shall be smooth, continuous, free from gross imperfections such as bare spots, lumps, blisters and inclusions of flux, ash or dross. Edges shall be clean and surfaces bright.

Bolts, nuts and washers shall be hot-dip galvanised and subsequently centrifuged in accordance with BS.729. Nuts shall be tapped up to 0.4mm oversize before galvanising and the threads oiled to permit the nuts to be finger turned on the bolt for the full depth of the nuts.

During off-loading and erection nylon slings shall be used. Galvanised work which is to be stored in works or on site shall be stacked so as to provide adequate ventilation to all surfaces to avoid wet storage staining.

Small areas of the galvanised coating damaged in any way shall be restored by:

i) Cleaning the area of any weld slag and thoroughly wire brushing to give a clean surface.

ii) The application of two coats of zinc-rich paint (not less than 90 per cent zinc, dry film), or the application of a low melting-point zinc alloy repair rod or powder to the damaged area, which is heated at 300^{o}C.

Where surfaces of galvanised steelworks are to be in contact with aggressive solutions and/or atmospheres the galvanising shall receive further protection by painting.

215.4 PLACING OF ROOFING SHEETS

The fixing of corrugated roofing sheets to the structure shall be done by hook bolts of at least 6 mm. diameter. The lower end of the bolt shall be bent to a shape that will grip the purlin on three sides. The upper end of the hook bolt shall be threaded and shall be equipped with a nut, a flexible washer (made of bituminous felt, or P.V.C., or as otherwise shown on the Drawings or required in the Particular Specification, or as directed by the Engineer) and a curved steel washer. All steel parts shall be galvanized. Holes in sheets shall be made by drilling; punching holes shall not be permitted. The diameter of drill holes shall be larger by 2 mm than the bolts and shall be in the ridge of the second corrugation from the edge. The direction of laying, distance between purlins, and the longitudinal and side laps shall be in accordance with the relevant B.S. and/or C.P. listed in Section 215.2 above, or as directed by the Engineer.

No more than two sheets shall be connected by one bolt; where four sheets overlap, the corners of the two intermediate sheets shall be removed.

Cutting of sheets shall be neatly done by hand-saw to exact measures.

Fixing of the roofing sheets shall not be too rigid in order to make allowance for slight shrinkage and curling. Standing or walking on the roof sheets shall not be permitted unless walkways are provided or other safety measures are taken.

215.5 FITTINGS

Wherever shown on the Drawings or directed by the Engineer, the Contractor shall install fittings such as eaves fittings (eaves filler pieces, corrugation closure pieces etc.), apex fittings (ridge pieces, vent ridge pieces, apex lining pieces etc.), fittings for verges, corners, edges, openings etc., flashing pieces, louvres and any other fittings sheets with which they are to be installed.

215.6 WORKMANSHIP

The quality of roofing sheets placed and the workmanship applied shall be such as to provide a perfect protection against rainfall. The Contractor shall be solely responsible for the roof being absolutely watertight and weatherproof.

215.7 TANK COVERS

Tanks shall conform to the following:

a) Tank covers are to be provided where specified in order to retain odours. They shall be purpose designed and manufactured for the particular application from ultraviolet resistant Glass Reinforced Plastic (GRP) or glass-coated steel, and shall be provided with all necessary ribs and stiffeners on the underside to provide a rigid and robust structure.

b) They shall rise from the tank walls to the centre of the tank, shall be self-draining, and shall not sag or form hollows.

c) They shall be suitable for use with sewage sludge and sludge gases, including those dissolved in water.

d) GRP covers shall comply with the relevant provisions of BS 4994 as appropriate. Glass coated steel covers shall comply with the specification requirements for glass coated steel tanks, as appropriate.

e) Loadings shall be in accordance with the provisions of BS 6399 (Roofs with no access) except where permanent access is specifically provided, in which case loadings shall be to BS 6399 (Roofs with access). In the case of GRP roofs, the maximum strain shall be limited to 0.3%. Calculations shall be provided for all roofs and covers.

f) The corners and edges of cover panels shall be smooth and uniform. All joints (viz. panels to wall, panels to bridge or panel to panel) shall be sealed with a flexible strip and plaint sealant to produce a close seal. The joints around openings, such as hatch covers, shall be sealed with a flexible strip firmly attached to the fixed portion of the covers.

g) Each cover shall incorporate 2 No. hinged, locking manholes at positions to be agreed, not less than 0.8m square. The lids shall be strengthened to prevent twisting on opening and shall be designed to fold back flat on opening with securely fixed handles.

h) The manhole and tank covers shall be strengthened at the point of attachment of the hinges, to ensure that hinge fastenings cannot pull through. The cover openings shall be strengthened to allow a ladder to be inserted in the manhole and to rest on the edge without damage to the manhole surround. The manholes shall be located at the outer edge of the tank and positioned for easy access and safe operation.

i) Adjacent to each manhole cover shall be provided a separate 200mm diameter stiffened opening with a sealing plate for instrumentation use. Where the covers are to be fitted to a tank at a roof height of more than 2.0m above ground level, suitable safety harness fixing points shall be provided adjacent to each manhole opening.

j) Each cover shall be provided with 2 No. 500mm square openings, one near the centre, one at the edge, in positions to be agreed, with stiffened edges, for fitting of ventilation equipment, and shall be sealed with removable plates.

k) In cases where the covers are to be supplied together with new tanks or new scraper bridges, then they shall be designed in co-operation with the relevant manufacturers to ensure compatibility.

l) Where specified and where necessary for machinery access, special sealed access openings shall be provided shaped to suite the machinery concerned.

m) The method of fixing and sealing to the tank walls shall be for the supplier to decide, and shall be stated in the Tender. All supports, fixings etc. shall be manufactured from corrosion resistant materials. Galvanised or plated mild steel is not acceptable.

215.8 METHODS OF MEASUREMENT AND PAYMENT

Measurement of roofing for payment shall be in square meters of the net area covered by the roofing, measured on the slope. Laps shall not be measured for payment. Unless specific items are provided in the Bill of Quantities, the cost of all fittings shall be deemed to be included in the unit rates for roofing and shall not be paid for separately.

The unit rates for roofing shall include for: supply of all materials and auxiliary materials; transportation and handling; placing and fixing; and for all materials, equipment and labour necessary for the completion of the roofing in accordance with the Drawings and the Specification and to the Engineer’s satisfaction.

216 - STEEL STRUCTURES

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216 STEEL STRUCTURES

216.1 GENERAL

The work required under this Chapter includes the fabrication and erection of structural steelwork such as steel columns, beams, trusses, platforms and the like. Non-structural metalwork such as doors, windows, gratings, handrails, etc. is treated in Divisions 209 and 210.

All steel structures shall be fabricated and erected or installed in strict accordance with the dimensions and details shown on the Drawings or determined by the Engineer and shall comply with the best accepted standards of workmanship to the complete satisfaction of the Engineer.

The Contractor shall supply all required materials, shall fabricate the steel parts, shall transport them to the Site of Works and shall erect and install them in their proper position and paint them.

216.2 MATERIALS

All materials used in fabrication, erection and painting of structural steelworks shall be new, of first-grade quality without rolling defects, cracks, grooves or rough surfaces and shall comply with the requirements specified on the Drawings and/or in the Particular Specification, and with the requirements of B.S. 4360 Grade 40, B.S. 4848 and other relevant British Standards.

216.3 WORKMANSHIP

216.3.1 Preparation of Members

All steel shapes, bars, plates, pipes, etc. shall be cut, drilled, bent and otherwise worked to the exact lines and dimensions shown on the Drawings. All burrs resulting from cutting and drilling shall be neatly removed. Where cutting is done by oxyacetylene torch, cut surfaces shall be clean and smooth.

Steel shall be worked either cold or red-hot, but not at medium (blue) temperature. Bolt holes shall be made by drilling only, and shall be accurately positioned so that bolts can be easily inserted.

Parts requiring machining shall be worked to the exact required dimensions in accordance with the Drawings and the finish shall be as marked on them, or, in the absence of such markings, shall be suitable to the purpose for which that parts are intended.

216.3.2 Weld Connections

All welding shall be done by the shielded metal-arc method by experienced welders qualified in accordance with B.S. 4871 to the highest standards of workmanship and to the satisfaction of the Engineer. The electrodes for steel welding shall be of a kind and class approved by the Engineer. The electrodes shall be stored in the original unopened containers. Electrodes in

open containers shall be protected from dirt and moisture. The surfaces of the parts to be welded shall be well cleaned of dirt, rust, slag, and paint. All slag and splatter adhering to the metal shall also be removed.

All metal parts and the electrodes shall be completely dry during welding. In case of rain or wind, all outdoor welding shall be stopped unless the metal parts are suitably protected to the satisfaction of the Engineer. Welding shall be carried out to ensure full penetration to the root of the joint in case of but joints and in all events complete fusion of the weld metal with the base metal and with other layers of weld metal. In case of multi-layer welding, each completed layer shall be cleaned of all slag and dirt before applying the next layer.

Special care shall be taken in cleaning the root bead of butt welds. The completed welds shall be free of defects, such as gas pockets, slag inclusions, undercuts, incomplete penetration or incomplete fusion. The shape and dimensions of the welding shall be as shown on the Drawings.

No quenching of welds by means of immersion in water or flushing or other means shall be permitted, but the welds shall be allowed to cool off gradually to the ambient temperature. Where required, welded elements shall be stress relieved.

216.3.3 Bolt Connections

All holes in parts for bolt connections shall be accurately matched in order to permit easy insertion of the bolts. In case of small inaccuracies reaming with a suitable reamer will be permitted.

Before making the connection, burrs shall be removed from the hole edges and the areas of contact cleaned. Fitting together parts by force or insertion of bolts by hammer blows will not be permitted. The bolts used for connection of the parts shall be of a standard whitworth or metric thread, with hexagonal head and nut. Suitable washers shall be used, and bolt ends shall protrude about 5 mm. from the nuts. The length of thread inside the connected part shall not exceed 3 mm. Tightening up of the bolts shall be done so as to ensure a rigid and permanent connection between the connected parts, without exceeding the permissible stresses. The contact surfaces of the parts to be connected by bolts shall be painted with red lead before the connection is made.

216.3.4 Assembly

The parts of the structural steel work shall be completely shop assembled unless otherwise marked on the Drawings or directed by the Engineer in consideration of traffic needs. In such cases, site assembly will be permitted and the Contract shall prepare in the workshop all holes, bolts, welding bevels, etc., required for the assembly on site. All parts subject to site assembly shall be marked and matchmarked in black paint, and shall be trial assembled at the shop before shipment.

the Engineer will check the parts after their assembly, but before their final connection, and will accept them if found satisfactory and conforming to the requirements of the Specification and Drawings. The Contractor shall not connect the parts together and shall not embed them in concrete until the receipt of the Engineer’s approval to do so.

216.3.5 Erection

All structural steelwork shall be erected and installed to the exact lines and positions shown on the Drawings or directed by the Engineer and shall be well anchored to the concrete structures.

After the Contractor has presented the parts of structural steelwork for the Engineer's inspection and obtained his approval, he shall transport them to the Site and set them in the required positions. When transporting such parts, the Contractor shall take care to prevent any damage or distortion to the frames or to the primary coat of paint already applied at the place of fabrication. Embedding into concrete, setting into position, etc. shall be exact and correct in accordance with the best accepted standards of workmanship. Setting the parts of the structure in position and their adjustment shall be first checked by water level and plumbline and the final setting shall be checked by surveyor's level.

The cranes, derricks, scaffolds, temporary supports and temporary connections used in the erection of the structural elements shall be such as will ensure the stability of the structure and safety of persons and prevent any damage, distortion, dislocation or undesirable stresses being caused to the structural elements. Temporary supports and connections shall not be removed until the final connections have been made and approved by the Engineer, but such approval shall not relieve the Contractor of his responsibility for the correct erection, stability and safety of the structure.

Unless installation by grouting-in anchor bolts or use of expansion anchors in previously prepared recesses is approved, anchor bolts and metal parts to be embedded in concrete shall be placed in position before casting of concrete and shall be held firmly and accurately in position while the concrete is being placed.

216.3.6 Painting

Painting of metal parts shall be in accordance with Subsections 207.1.7(d) and 207.9 above.

Cleaning and priming of metal parts shall be done at the workshop prior to transporting to the Site. Parts intended to be welded on the Site during erection may be painted with a weldable primer approved by the Engineer.

The application of specific paints, such as epoxy or rubber base shall be according to the Particular Specification and/or the Engineer's instructions.

216.3.7 Glass Coated Steel Tanks

a) Tanks shall be constructed of glass-coated steel panels erected on a concrete base or of other approved construction. The structural design, materials and construction of the tanks is to be in accordance with all British (or foreign) Standards and Codes of Practice current at the date of Tender.

b) Imposed loads due to snow and wind shall be in accordance with BS 6399. The tank walls shall be designed to support any roof structure, bridges, scrapers or other appurtenances to be fitted to the tanks.

c) The installed glass coatings shall have the following properties:

- adhesion bond strength of at least 34500 kN/m2
- thickness between 0.18mm and 0.28mm each side
- no permeability and zero moisture absorption
- resistance to pH solutions in the range 3 to 9
- ability to flex with the steel substrate without sapling or cracking
- the ability to be repaired on site.

d) All holes and openings in panels greater than 25mm shall be made before glass coating, and non-destructive testing shall be carried out for dry film thickness and porosity before leaving the factory. Test certificates shall be supplied before delivery.

e) Panels shall be jointed with suitably protected bolts and shall be sealed with polyurethane or other approved sealant which shall be applied to all joints and edges of plates.

f) Each tank shall be provided with all necessary factory made pipework and instrumentation connections as shown in the Drawings or specified.

216.4 METHODS OF MEASUREMENT AND PAYMENT

Measurement of structural steel for payment shall be per unit of measurements shown in the Bill of Quantities such as: weight, unit, length etc.

The unit rates for the fabrication and erection of steel structures shall include for the cost of all labour and materials, including but not being limited to: supply of all steel and auxiliary materials, transport to workshop, fabrication of parts, workshop painting as specified, transport to Site, storage, and erection according to Drawings and Specification or as directed by the Engineer and final painting of erected structure.

217 - PIPELINES AND PIPEWORKS

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217 PIPELINES AND PIPEWORKS

217.1 SCOPE

This part of the specification shall apply to the supply, delivery, laying, jointing and testing of all pipes, fittings and accessories, and includes:

Concrete pipes
Asbestos-Cement pipes
Steel pipes
Cast Iron and ductile Iron pipes
G.R.P. pipes
P.V.C. pipes
HDPE pipes

217.2 CONCRETE PIPES

217.2.1 Quality Requirements

Concrete pipes, fittings and junctions shall comply in all respects with B.S. 5911 or ASTM C76M for reinforced concrete pipes or with B.S.5911 or ASTMC14M or DIN4032 for non reinforced concrete pipes. The pipes shall be truly circular and have bell joints, or spigot and socket joints, or rubber gasket joints, as noted on the Drawings or in the Bill of Quantities, and as specified hereafter.

Concrete pipes, fittings and junctions shall be tested for compliance with B.S. 5911 (and BS EN681-1:96 or DIN 4060/2 for jointing system) in approved laboratories or in their place of manufacture. The pipes shall be subjected to Hydraulic and Crushing Tests. The number and selection of samples for testing, the test procedures and the requirements shall all be as specified in B.S. 5911.

The selection of samples and the Tests shall be witnessed by a representative of the Engineer, who shall be informed at least 48 hours in advance of any sampling or testing.

The cost of samples, their transportation to the test site and their testing shall be deemed to be included in the unit rates and shall not be paid for separately.

Alternatively, the Contractor may submit to the Engineer certificates from approved laboratories certifying that the pipes have been subjected to and have satisfactorily undergone the required tests according to the specified standards. In that case the Engineer shall be entitled (but shall not be bound) to renounce any further testing.

The concrete pipes should be protected by HDPE lining, (according to DIN 50 049-2.2) or PVC lining or should have an epoxy coal tar interior coating not less than 1000 microns thick.

217.2.2 Hauling and Handling of Pipes

The entire curing period of the pipes shall be completed before any pipe shall be loaded and transported. The Contractor shall check each pipe before loading and shall reject all damaged or defective pipes. The Contractor shall load with the greatest care and properly secure the pipes on the vehicles for transportation and take all necessary measures to prevent any damage to the pipes during transport. The Contractor shall be responsible for the quality of the pipes and for their condition upon and after delivery to the Site. The Engineer will check the pipes upon their delivery to the Site and the Contractor shall forthwith remove from the Site all rejected pipes and replace them at his own expenses by pipes acceptable to the Engineer. Only pipes inspected and accepted on the Site by the Engineer shall be incorporated in the Works.

The Contractor shall ensure that all pipes are properly handled by his staff. During transport, pipes shall not be allowed to rest on their joints, narrow cross-members of vehicles, or anything else that might give rise to concentrated loads due to the weight of the pipe or bumping of the vehicle but shall be properly supported on soft material. Sufficient labour and equipment shall be on hand before loading and unloading is commenced and under no circumstances shall any pipe be dropped from a vehicle. For storage on site, the ground must be level and free from loose stones.

The Engineer shall have the right to reject consignments or stocks of pipes from which failed pipes have been drawn, or order them to be pressure-tested outside the pipelines, even though no defects are apparent, if there is reason to believe that mishandling has taken place. All costs incurred in this respect shall be borne by the Contractor.

217.2.3 Laying of Pipes

After the excavation and preparation of a section of pipe trench has been completed by the contractor, it shall be inspected by the Engineer. No pipe shall be laid before the excavation has been approved by the Engineer. Just before pipelaying, the trench shall be cleaned of all stones, soil and other debris that might have fallen therein.

All pipelaying shall be carried out by experienced pipe-layers well skilled in this work. Pipes shall be laid true to line by means of a line stretched along the side of the pipes and true to level by means of a straight edge of 4 meters in length kept inside the pipes and pulled forward to pegs boned in at suitable intervals between sight rails set to the proper levels.

Immediately before being laid, each pipe and fitting shall be carefully examined both inside and outside for any damage, and all dust, dirt and foreign matter shall be removed. Care shall be taken to ensure that they remain clean during laying. The use of a badger will be ordered by the Engineer, if, in his opinion, dirt is not being satisfactorily excluded. The badger on a sound rope is to remain within the bore of the pipe previously laid and jointed and is to be drawn forward as the work proceeds throughout the whole length of the conduit. The badger is to be of soft material which will not damage the internal surfaces of the pipes.

In order to prevent stones, soil or small animals from entering the pipe, a suitable cap end or plug shall be provided with which the last pipe laid shall be sealed when pipelaying is not actually in progress. The plug shall be of the screw-up expanding type or of tapered wood.

The completed section between two manholes shall form one continuous tube well supported over its entire length and with a straight and even invert according to the lines and grades shown on the Drawings. The straightness of each section between manholes shall be checked externally by means of a string stretched parallel to the designed invert line and supported at intervals not exceeding 7.5 m, and internally by means of a beam of light. The maximum permissible deviation in invert level in one section shall not exceed 2.0 cm or 1 mm per pipe, whichever is less. The alignment and location in plan shall not deviate by more than 20 cm from the design line. The axial displacement of pipes entering any manhole and issuing from it shall not exceed 2 cm. Pipelaying shall proceed upstream with the bells or sockets of the pipes pointing upstream.

Where shown on the Drawings or required by the Engineer, concrete pipes shall be laid on a sand bedding, or concrete bedding or with concrete surround.

217.2.4 Jointing

Rubber Gasket Joints - Where pipes with bell and spigot joints and rubber sealing gaskets are approved by the Engineer, the following provisions shall apply to jointing: rubber gaskets shall be of synthetic rubber resistant to oils and fats, and shall meet the requirements of (B.S. EN681-1 or DIN 4060/2) - Elastomeric Joint Rings for Pipework and Pipelines (Types 1 and 2) or of I.S.O. 1398.

All pipes, and especially the bells and spigots, as well as the rubber gaskets shall be carefully inspected before being incorporated into the work, and no defective pipes or gaskets shall be used. Before making any joints, the rubber gaskets, spigot and bell shall be well cleaned and thoroughly covered with a special lubricating compound not harmful to rubber, as approved by the Engineer. After lubrication, the rubber gasket shall be stretched around the spigot of the pipe to be laid and fitted into the groove, care being taken to ensure uniform tension and to prevent twisting of the gasket. The spigot with the gasket on it shall then be inserted into the bell of the previously laid pipe and the new pipe shoved into position. Shoving-in may be done while the pipe is still suspended from the crane or lifting tackle to minimize friction between pipe barrel and trench bottom.

The bell, spigot, and gasket shall be protected from contact with earth, dirt, or any other deleterious matter until the joint is completed. The use of undue force to overcome improper fitting of the gasket into the spigot groove shall not be permitted, since this may cause twisting or dislocation of the gasket resulting in a faulty joint. If the pipes are properly aligned, the gasket properly fitted and the gasket and bell well lubricated, the pipe should slide in smoothly without the application of much force.

217.2.5 Cast-in-Situ R.C. Conduits

Cast-in-Situ R.C. conduits shall conform to all relevant sections of this Specification with regard to concrete, reinforcement, shuttering, etc. All cast-in-situ R.C. conduits shall be made of grade C30P, unless otherwise noted.

Cast-in-situ R.C. conduits shall be perfectly true to dimensions in cross section. Construction joints shall be installed along the conduit at intervals shown on the Drawings and between joints the conduit shall be cast continuously, with no interruption.

The bottom of the trench shall be excavated by hand to the longitudinal slope of the conduit, and to the exact shape of the bottom of the conduit, moistened and well compacted. On the

ground, a 5 cm blinding layer of lean concrete grade C7P shall be cast, to the longitudinal slope of the conduit, as a base for the bottom horizontal and inclined surfaces of the conduit, as shown on the Drawings.

Generally, conduits shall be cast in two vertical lifts, with a keyed construction joint separating these lifts, in accordance with the Drawings. Great care shall be exercised in pouring the lower lift, to ensure that the space directly under the interior form is completely and densely filled with concrete. In pouring the upper lift, concrete shall be placed equally on both sides of the form, to minimize lateral pressures on it. The internal surface of the conduits shall be smooth, perfectly true, and free of any irregularities.

Where permitted in writing by the Engineer, precast elements may be incorporated in cast-in-situ R.C. conduits. Such precast elements shall be manufactured and installed in the cast-in-situ conduit in accordance with the specification and the instructions of the Engineer.

217.2.6 Inspection and Testing of Concrete Gravity Pipelines

(a) General - After the laying and jointing of a section of pipeline (defined as the length of pipeline between two adjoining manholes) has been completed, that section shall be inspected and tested, as specified hereafter. The joints shall remain exposed, joint grooves shall not be filled and any bedding or surround or backfill shall be carried no higher than the invert of the pipe until all inspections and tests have been completed to the satisfaction of the Engineer and until he has given permission in writing to proceed with the covering-up of the pipeline.

The following inspections and tests shall be carried out:

Visual Inspection, in which the Engineer shall inspect the section for grade, direction, line, appearance of inner surface, depth and correct jointing.

Hydrostatic Test, as specified hereafter, which will be carried out in the presence of the Engineer.

After the completion of the above inspection and test to the satisfaction of the Engineer, any required beddings and/or surrounds shall be completed and backfilling shall be carried out as specified in Part 2 Section 201.3 of this Specification.

The Contractor shall inform the Engineer at least 24 hours before a section is ready for inspection and testing.

(b) Hydrostatic Test - The water tightness of every completed section between two manholes shall be tested by a hydrostatic test as hereinafter described. The section to be tested shall be cleared of any material or object that may be lying in it and all bellholes shall be cleaned so that the joints may be observed from the outside. The two ends of the section shall be hermetically sealed by suitable temporary plugs provided with pipe nipples. The upstream plug shall be connected to a standpipe extending at least 4 m above the top of the highest pipe. Water shall then be introduced through the opening in the lower pipe end to fill the pipe and expel the air through the standpipe, until the water level in the standpipe is 4 m above the top of the highest pipe. The section shall then be permitted to absorb water for 24-48 hours and all visible leaks in the joints shall be repaired. After this period the water level shall be restored and the pipe observed for 2 hours, while the water level in the standpipe is being maintained at 4 m above the highest pipe. The quantity of water that must be added to maintain the water level in the standpipe shall be measured and this will

be considered as the leakage of the tested section. The leakage under test, for pipeline diameter ≤ 400 mm, shall not exceed 0.8 litre/m2 of internal wall pipe area per hour and for pipeline diameter > 400 mm, the leakage shall not exceed 0.8% of inside pipe volume per hour. If the leakage during the test period exceeds the permissible rate, the Contractor shall search for and make good all defects causing such leakage. The test and repairs shall be repeated as often as necessary until all visible leaks have been repaired and the leakage does not exceed the permitted limit.

All necessary testing apparatus, expanding plugs, stoppers, bladders etc., labour, water and any other materials necessary shall be provided by the Contractor at his own expense.

(c) Infiltration Test - Where the line has been laid in groundwater, after the trench has been backfilled, the interior of the pipe shall be tested for infiltration of external water through the joints into the interior of the pipe. Any leak so detected shall be repaired as instructed by the Engineer and to his entire satisfaction and the pipeline shall be retested, all at the Contractor's own expense.

217.2.7 Final Cleaning and Inspection

Before the works are accepted by the Engineer, the entire pipe system, including all structures, shall be thoroughly cleaned by flushing or by passing a brush, sphere or other suitable tool through it, or by any other approved method, to ensure that it is clean, and free of obstructions and that pipe runs are perfectly straight. Before taking over, the pipeline will be finally inspected by the Engineer.

217.2.8 Methods of Measurement and Payment

Precast concrete pipes and cast-in-situ R.C. conduits shall be classified for payment according to type and diameter and shall be measured for payment in linear meters of completed pipeline in place, measured along the crown of the pipeline, between internal surfaces of manholes or chambers and the length measured for payment shall include the lengths of all fittings, specials, junctions, bends, etc. installed in the pipeline.

The price of fittings, specials, bends, junctions, etc. for precast concrete pipes and cast-in-situ R.C. conduits shall be, unless otherwise specified in the particular specifications or the B.O.Q. considered as included in the cost of pipes.

Alternatively, if so stated in the Particular Specification and/or in the Bill of Quantities, precast concrete pipes and fittings may be measured by number of pipes of defined net lengths and by number of fittings.

Payment for precast concrete pipes and for fittings, specials, etc., shall include:

(a) Supply, hauling, handling, unloading and stacking of pipes and fittings including all necessary jointing materials.

(b) Removal from stacks; hauling and stringing alongside trench; laying, jointing and testing at any depth of trench; connections to manholes and chambers; and final cleaning and flushing of pipeline. The unit rates for this item, for each type and diameter of pipe and fitting, shall be the same for all depths of trench in which the pipes and fittings are to be installed.

Payment for each type and diameter of cast-in-situ R.C. conduits shall be made under a single item in the Bill of Quantities and payment for each type and diameter of bend, junction etc. for cast-in-situ conduits shall be made under a single "extra-over" item in the Bill of Quantities, and each of these unit rates shall include for the blinding layer, formwork, concrete, reinforcing steel, joints, curing, testing and all labour and materials necessary to construct and complete the cast-in-situ R.C. conduit.

The unit rates for constructing each type and diameter of cast-in-situ conduit and fittings, junctions etc. shall be the same for all depths of trench in which the conduits and fittings are to be constructed.
Only pipes, fittings, junctions, bends, etc. actually laid in trench, and tested and accepted by the Engineer, shall be measured for payment above, and no allowance whatsoever will be made for any breakage, loss, etc. en route.

Excavation and backfill, special beddings, surrounds and manholes shall be paid for under separate items in the Bill of Quantities, unless otherwise noted.

217.3 ASBESTOS CEMENT PIPES AND FITTINGS

217.3.1 Quality Requirements

All asbestos cement pipes, joints, specials and fittings shall be supplied by the Contractor unless otherwise stated. They shall be made by an approved manufacturer and shall be of the class and nominal diameter as shown on the Drawings and shall comply in all respects with the following standards:

Gravity Flow Pipes - for conveying fluids at working pressures up to but not exceeding 1.0 kg/cm^2 - B.S. 3656 or I.S.O. R-881

Pressure Flow Pipes - for conveying fluids at working pressures exceeding 1.0 kg/cm^2- B.S. 486 or I.S.O. R-160

The standard joint used on the A.C. pipes shall be the "Simplex", or "Supersimplex" (Comet, kaltite, Reka or similar) type coupling consisting of asbestos-cement sleeves and self-sealing rubber gaskets, and complying with the above standards.

Cast iron detachable joints and long collar detachable joints and other cast iron fittings for use with asbestos cement pipes shall comply with the requirements of B.S. 486 and shall be supplied with rubber rings, bolts and nuts, etc. The external diameters of all cast iron joints and fittings shall be adapted to the external diameter of the asbestos cement pipes of the corresponding nominal diameters.

Unless otherwise stated, A.C. pipes shall be coated and lined as provided under Clause 2.3 of B.S. 486. Cast iron joints and fittings for A.C. pipes shall be coated and lined as specified for C.I. pipes.

Rubber gaskets shall be of synthetic rubber and shall meet the requirements of B.S. 2494 or I.S.O. 1398, for water pipes or drainage, whichever is applicable.

The Contractor shall supply all the necessary asbestos-cement and cast iron fittings, such as reducers, bends, tees, crosses, end caps, adaptors, etc. All such fittings shall match the pipes they are to be connected to in diameter and class. All pipes, fittings, couplings, and gaskets shall be obtained from approved manufacturers who shall supervise the transportation and

laying of the pipes and shall guarantee the quality of the pipes and fittings for a period not less than the period of maintenance specified in this Contract.

The Contractor shall submit to the Engineer certificates from approved laboratories that the pipes have been subjected to and have satisfactorily undergone the tests specified in the above-mentioned standards and have satisfied all their requirements.

217.3.2 Hauling and Handling of Pipes and Couplings

No pipe shall be loaded for transportation or transported until after the end of the curing period. The Contractor shall check each pipe before loading and shall reject every pipe found to be damaged or defective. The Contractor shall properly secure all the pipes on the vehicles and take all necessary measures to prevent any damage to the pipes. The Contractor will be held responsible for the quality of the pipes and for their condition after delivery to the Site. The loading, transportation and unloading of the pipes shall be done with the greatest care. Under no circumstances shall pipes be thrown down on the ground or dragged along it. Pipes up to 6" in diameter may be unloaded by two workmen standing on the vehicle and handing them down to two other workers standing below who shall place them and stack them gently on the ground. Alternatively these pipes may be unloaded by rolling them down gently and carefully from the truck on two strong planks and placing them alongside the trench in which they are to be laid. Larger pipes shall be handled by suitable cranes. Care shall be taken not to damage the edges of the pipes during unloading operations. The rubber rings of the joints shall be supplied separately from the couplings and shall be stored in the shade and in dustproof containers. Where conditions do not allow for the stringing of pipes alongside the trench into which they are to be laid, they may be unloaded at a central point, stacked on planks and secured by stop blocks until they are required in the Works.

The Engineer will check the pipes on the Site and the Contractor shall mark all defective or damaged pipes in accordance with the Engineer's instructions and shall remove them from the Site immediately and replace them with acceptable pipes at his own expense. Only pipes marked as accepted by the Engineer after inspection on the Site shall be incorporated in the Works.

217.3.3 Mounting of Joint Couplings

The rubber gaskets shall be brought to the Site separately and shall not be inserted into the joint couplings until immediately before the mounting of the joint. As far as practicable, the coupling shall be mounted on the pipe end before the pipe is lowered into the trench. Before assembly, the coupling grooves, rubber gaskets and pipe ends shall be thoroughly cleaned and lubricated with a lubricant provided or approved by the pipe manufacturer. One sealing gasket and the central spacing ring (or spacers) shall be inserted in their respective grooves. Since the sealing gaskets have a special asymmetric cross section, care shall be taken to insert them in the correct direction. Gaskets and spacing rings shall be placed in their grooves neatly and evenly without twists, distortion or bulges. The coupling shall then be slipped on to the pipe end until the spacing ring or spacers rest against the edge of the pipe. On large diameter pipes (450 mm and above) a mounting tool operated by a screwed rod or similar device shall be used to pull the coupling over the pipe end. Where no spacing rings or spacers are provided a special fixing clip shall be used to keep the coupling in place while the next pipe is inserted into it.

217.3.4 Laying and Jointing of Asbestos-Cement Pipelines - General

Attention is drawn to the necessity of ensuring a perfectly even bed for the pipes. Where shown on the Drawings or required by the Engineer, asbestos-cement pipes shall be laid on a sand bedding placed in accordance with Part 2 Section 201.3.7. Bellholes sufficient in size to permit jointing of pipes as described hereinafter shall be excavated in the trench bottom, bedding and trench walls as necessary. No pipe shall be laid until the surface of the excavated trench bottom or that of the sand bedding, as the case may be, has been inspected by the Engineer and approved for pipelaying.

Before the line is handed over to the Employer, the inside of all pipes shall be cleaned of all dirt, mortar and other foreign matter. At the end of each work day and after a pipeline section is completed, the open pipe ends shall be suitably plugged to prevent entry of dirt or small animals.

All pipes shall be placed in position carefully and shall be laid true to line and grade. Under no circumstances shall pipes be thrown into the trench. Lowering shall be carried out manually or by means of lifting tackle and/or ropes. Before any pipe is lowered into the trench, it shall be cleaned and examined for cracks and flaws. If undamaged it shall be placed in position ready for jointing in accordance with the requirements hereinafter.

217.3.5 Laying A.C. Gravity Flow Pipes

Asbestos-cement pipes in gravity flow lines shall be laid consecutively in straight lines between adjacent inspection manholes. Special joint couplings shall be built into the walls of the manholes to ensure a tight joint between pipe and manhole. After being laid and jointed the completed section between two manholes shall form one continuous tube, well supported over its entire length and with a straight and even invert according to the lines and grades shown on the Drawings. The straightness of each section between manholes shall be checked externally by means of a string stretched parallel to the designed invert line and supported at intervals not exceeding 7.5 m, and internally by means of a beam of light (either torch or sunlight reflected by a mirror).

All pipes and manholes shall be laid and constructed according to the lines and grades shown on the Drawings, or as instructed by the Engineer, with the following tolerances:

The maximum permissible deviation in invert level in one section shall not exceed 2.0 cm or 1 mm per pipe, whichever is less. The alignment and location in plan shall not deviate by more than 20 cm from the design line. The axial displacement of pipes entering any manhole and issuing from it shall not exceed 2 cm.

217.3.6 Laying A.C. Pressure Pipes

In pressure lines the pipes shall be laid in straight lines where possible, but curves of long radius may be required, and these shall be obtained by deflection at the joints. Such deflections, however, unless specifically otherwise ordered by the Engineer, shall comply with the following:

ND (mm)	80 - 250	300 - 350	400 - 600	700 - 1200	≥ 1300
α Less than	4°	3°	2°	1 ½°	1°

Where a change in direction cannot be made by deflection at the joints of ordinary straight pipes, prefabricated bends shall be used. The approximate locations of such bends and other specials are indicated upon the Drawings, and their exact positions will be determined by the Engineer on the Site.

217.3.7 Jointing Asbestos-Cement Pipes

Before jointing a new pipe to one already laid in the trench, the second gasket shall be installed in the free end of the coupling mounted on the pipe in place, in the manner described above. The new pipe, with the joint coupling mounted on it shall be lowered into the trench, its free end cleaned, lubricated and inserted into the open end of the coupling on the pipe already in place. The pipe shall then be shoved home until its end abuts against the central spacing ring or spacers in the coupling. Small to medium size pipes may be shoved home by hand with or without the aid of crowbars. Larger size pipes, which are handled by means of cranes or hoists, may be shoved in while being suspended at balance point slightly lifted above the ground, thus eliminating friction with the trench bottom. Large size pipes may require the use of a special pulling device. Jointing shall always be done coaxially, any deflection in the joint as described in Subsection 217.3.6 above being produced after the joint has been completed.

217.3.8 Cutting of Asbestos-Cement Pipes

For closing lengths it will be necessary to cut asbestos-cement pipes. For this purpose, the Engineer may allow, at his discretion, the use of pipes with damaged ends but otherwise sound. Asbestos-cement pipes shall be cut by a suitable cutting machine, care being taken that the cut ends are truly perpendicular to the pipe axis and that no breaking or cracking occurs. Cutting by hammer and chisel will not be allowed.

For jointing, the outside diameter of the pipe ends shall then be reduced to the required distance, unless special pipes turned to the correct diameter are supplied by the manufacturer. Such reduction of outside diameter of pipe ends shall always be done with an approved machine mounted on or inside the pipe barrel; filing down by hand shall not be permitted. In every case the edges of the cut pipe ends shall be given the correct shape required for jointing.

217.3.9 Backfilling

As each pipe is placed in its final position and jointed, the trench shall be filled, leaving only the joints uncovered. The materials used for backfilling and their placing and compacting shall be in accordance with the Drawings and the requirements of the Specification. The joints shall be left uncovered until the hydrostatic tests have been successfully completed and the Engineer has given permission to cover the joints.

217.3.10 Testing of Asbestos-Cement Pipelines

A.C. pipelines shall be tested in accordance with standard I.S.O. 4483, and as specified hereafter and as directed by the Engineer:

(a) Gravity Pipelines - Gravity pipelines shall be subjected to the tests and shall meet the requirements prescribed for concrete gravity lines in Subsection 217.2.6.

(b) Pressure Pipelines - Pressure pipelines shall undergo a hydrostatic pressure test. They shall be tested in sections not larger than 500 m, or as may be directed by the Engineer, and tests shall be made only on sections which are completed, except for backfilling over joints and fittings which are to be left exposed for inspection. Weights and thrust blocks intended to prevent lateral and vertical displacement of the pipes or specials must be completed and must have attained their design strength before tests are commenced.

Test sections shall be preferably carried out between shut-off or sectioning valves. Where this is not practicable, test sections shall be sealed off by suitable bulkheads, properly braced.

Prior to testing, air shall be evacuated from the line by filling it with water with all valves and taps open. After the first filling and the closing of all valves and taps, the water shall remain in the line for at least 48 hours to allow for absorption, and water being added as required to make up for losses. During this period the Contractor shall inspect the line and all fittings and valves installed on it for leaks. Any leaks found shall be promptly repaired by the Contractor, who shall then proceed with the test, unless otherwise noted on the drawings, in the particular specifications, or by the Engineer, the "Test presssure" measured at the lowest point of the section shall be equal to one of the following values:

For pressure gravity driven pipelines:

(a) (1.5 x Rated Working Pressure) for rated working pressure equal to or less than 10 kg/cm^2 or the static pressure whichever is higher.
(b) (Rated Working Pressure + 5.0 kg/cm^2.) for rated working pressures exceeding 10kg/cm^2 or the static pressure whichever is higher.

For lift pipelines:

Rated working pressure plus calculated water hammer surge plus 2Kgf/cm^2. The water hammer surge will be calculated as follows: $\Delta H = \frac{a\,\Delta V}{g}$

where:

ΔH = Water hammer surge
ΔV = design velocity as indicated on the drawings expressed as meter per second.
a = surge velocity expressed as meter per second (a = 1100m/s).
g = acceleration due to gravity in meters per second per second = 9.81 m/s^2.

The pressure shall be slowly raised by pumping to the required "Test Pressure". Pumping shall then be discontinued, the pump disconnected, and the line kept under pressure for at least 15 minutes. For the line to be accepted, the pressure shall not drop by more than 10% during the said 15 minute period and there shall be no visible leaks at joints, fittings, valves, etc. Should the drop of pressure exceed this value, the Contractor shall search for the defects causing such pressure drop, shall make all necessary repairs and repeat the test until the section under test meets the requirements. Provided always that all visible leaks must be repaired whatever the loss of pressure. The Contractor shall at his own cost provide all necessary test pumps, pressure gauges, cocks and other accessories and shall make such temporary connections as may be required for filling and testing the line in the manner herein specified.

The water used for pressure testing shall be provided by the Contractor and shall be free from inpurities and of such a quality which will not pollute or injure the pipeline. The Contractor shall be responsible for obtaining the water, transporting it and for its safe disposal on completion.

217.3.11 Methods of Measurement and Payment

Asbestos-Cement pipes shall be classified for payment according to type, diameter and class and shall be measured in linear meters of completed pipeline in place measured along the crown of the pipeline as follows:

- In gravity flow lines: between internal surfaces of manhole or chambers.
- In pressure flow lines: between stations.

The length measured for payment shall include the lengths of all fittings, valves and specials installed in the line.

The price of fittings, specials, junctions, bends, etc. shall be considered as included in the cost of pipes, unless otherwise specified in the particular specifications or the B.O.Q.

Alternatively, if so stated in the Particular Specification and/or in the Bill of Quantities, pipes and fittings may be measured by numbers of pipes of defined net lengths and by number of fittings.

Payment for asbestos-cement pipes and for fittings, specials, etc. shall include:

- Supply, hauling, handling, unloading and stacking of pipes and fittings including all necessary A.C. joints and jointing materials for pipes and all A.C. and C.I. joints and jointing materials for fittings, specials, valves, etc.

- Removal from stacks; hauling and stringing alongside trench; laying and jointing of pipes and fittings at any depth of trench; connections to manholes and/or chambers, and final cleaning and flushing of pipeline. The unit rates for this item, for each type, class and diameter of pipe and fitting, shall be the same for all depths of trench in which the pipes and fittings are to be installed.

- Testing of complete pipeline:
  - For gravity pipelines: the cost of testing shall be included in the unit rates for pipes and shall not be paid separately.
  - For pressure pipelines: the cost of testing shall be paid for under a separate item in the Bill of Quantities, by linear meters of pipe tested.

Only pipes, fittings, junctions, bends etc. actually laid in trench and tested and accepted by the Engineer shall be measured for payment under the above items, and no allowance whatsoever will be made for any breakage, loss, etc.

Excavation and backfill, special beddings, surrounds and manholes and chambers and site test shall be paid for under separate items in the Bill of Quantities, unless otherwise noted.

217.4 STEEL PIPES AND FITTINGS

217.4.1 Quality Requirements

Steel pipes for use in the Works shall be made by an approved manufacturer and shall meet the requirements of B.S. 534, 1387, 3600 and 3601 or American Water Works Association

Standard C202, or equivalent European standards, carbon content shall not exceed 25 percent. Unless specified otherwise all steel pipes shall have minimum pipe wall thickness schedule 40 for nominal pressures up to PN 40, for higher pressures NP 64 and more wall thickness should comply with schedule 80.

Pipe ends shall generally be plain squared for jointing with Viking-Johnson type couplings, or bevelled for butt welding joints or flanged with flanges according to B.S. 4504 for flanged joints or with a bell on one end for fillet welded lap joints.

Unless otherwise specified or directed by the Engineer, fittings, bends, branches, specials etc. for use with steel pipes shall be prefabricated, factory made and shall be equal in quality and strength to steel pipes. Ends of fittings etc. shall be plain squared, bevelled or flanged to fit pipe ends.

Steel pipes and specials intended for laying below ground shall be cement-mortar lined or epoxy lined internally, and epoxy or bitumen coated externally not less than 150 micron thick. The hot bitumen of the coating shall be wrapped with bitumen saturated asbestos felt or glass-fibre mat and whitewashed. Other types of linings or coatings which may be required shall be as detailed in the Particular Specification. The ends of pipes shall be left uncoated for jointing. Sufficient lining, coating and wrapping materials and implements thereto shall be provided to complete coating on uncoated sections after jointing and to make good after laying of pipes.

Steel pipes and specials to be laid above ground in open air shall be epoxy or cement mortar on the inside and painted on the outside not less than 150 micron thick.

Steel pipes and specials to be laid inside buildings shall be epoxy coated internally and externally 150 microns minimum thickness.

Mechanical joints for use with steel pipes shall be of the Viking-Johnson sleeve type made by an approved manufacturer. The joints shall be watertight when assembled and shall be sufficiently flexible to permit small deflections without impairing their watertightness. Rubber rings to be used with joints shall comply with the requirements of B.S 2494. The Contractor shall supply sufficient quantities of specially sized pipes for cutting of closure pieces and of Johnson Couplings without centre register to permit the insertion of closing sections in the pipelines.

Galvanized and black iron pipes and fittings shall comply with B.S. 1387 (Steel Tubes and Tubulars Suitable for Screwing to B.S. 21 pipe threads). Fittings not included in B.S. 1387 shall comply with B.S. 143 (Malleable Pipe Fittings) heavy quality. Pipes and fittings ordered galvanized shall comply with the requirements of the applicable Clauses of the above-mentioned British Standards.

The Contractor shall submit to the Engineer certificates from approved laboratories certifying that the pipes and fittings supplied comply with the requirements of the relevant specifications.

217.4.2 Hauling and Handling of Pipes and Fittings

Pipes and fittings shall not be allowed to drop, roll freely or strike objects which may damage them. When fitting pipes or fittings by their open ends, special hooks or plates shaped to fit the wall shall be used. Chaining will be allowed on bare pipes only; wrapped pipes shall be lifted by padded straps at least 20 centimeters wide. Care shall be exercised in transporting,

handling or storing pipes and fittings in order to avoid distortion, flattening, denting, scoring or any other damage to pipes and fittings and to their outer coating and/or inner lining.

217.4.3 Stringing of Pipes

Pipes of the various diameters and wall thickness shall be strung along the alignment as closely as possible to their final position.

Pipes and fittings strung along the alignment shall be protected against intrusion of earth, mud, dirt and other foreign bodies, and against damage to the outer coating. Pipes shall not be strung on the side of the trench where excavation material has been or is to be placed. Where necessary or as directed by the Engineer gaps shall be left in stringing in order to allow movement of vehicles or men across the alignment. Wrapped pipes shall be whitewashed unless they have been supplied with whitewash and the latter is in good condition after stringing.

217.4.4 Handling of Mortar-Lined Steel Pipes

No internal hooks or similar equipment likely to damage the mortar lining shall be used. Excessive bending of the pipe that may cause cracking of the mortar lining shall be prevented.

217.4.5 Repairs of Defective Pipes

Should laminations, cracks or other defects be discovered on any pipe or its coating or its lining, the Engineer will issue instructions as to whether such defects shall be repaired or the defective part cut out or the defective pipe removed. Where the pipes were supplied by the Employer, he will pay the Contractor the cost of the repairs or other extra work necessitated thereby, but otherwise pipes shall be repaired or replaced by the Contractor at his own cost.

217.4.6 Welding of Pipes

(a) Welding Methods - All welds shall be made by the manual shielded metal-arc method. The welding procedure to be applied by the Contractor shall be submitted to the Engineer for approval, before the commencement of the work. All welding works shall be carried out by welders having passed the welders qualification tests in accordance with B.S. 4871 part 1 and B.S. 4872 part 1, whichever is applicable. Welds will be either butt welds for plain-ended pipe joints or fillet welds for lap joints (bell and spigot). The use of welding machines with two outlets will not be permitted; every welder shall work with a separate machine.

(b) Electrodes - Electrodes used for welding shall meet the requirements of B.S. 639 and B.S. 4215. Generally, with D.C. generators, Class E-100 (DCRP) electrodes shall be used. In any case, the electrodes proposed by the Contractor shall be subject to the Engineer's approval prior to their use.

Electrodes shall be stored in the unopened original containers in such a manner as to prevent absorption or loss of moisture or mechanical damage to the coating. Electrodes in open containers shall be protected against moisture. Electrodes that have been damaged, moistened or otherwise deteriorated, shall be rejected.

(c) Cleaning of Pipes - Pipe ends to be welded together shall be thoroughly cleaned of any dirt, oil, residues of paint and asphalt, and any other foreign matter that may adversely affect the quality of the weld. Paint and oil residues shall be removed with kerosene or gasoline.

(d) Welding of Joints - The number of beads in each weld seam shall be not less than two, and their thickness shall not exceed 3.0 mm.

In butt welds, the thickness and number of the beads shall be so adjusted that the height of the weld reinforcement shall be not less than 0.8 mm and not more than 1.5 mm above the pipe surface. The width of the cover bead shall be approximately 3.0 mm more than the width of the groove before welding. In fillet welds the thickness of the throat shall be at least $0.5\sqrt{2}$ (= 0.707) of the pipe wall thickness. Cutting back of the edge of the bell shall be kept to a minimum. All weld metal shall be thoroughly fused to the parent metal and to the previously placed weld metal.

After the completion of each bend, the weld shall be thoroughly cleaned of all scale, slag, or dirt. All spots on the weld where electrodes are changed shall also be cleaned. A peening hammer and steel brush may be used for cleaning, provided it is done to sound and bright metal. The finished seam shall be thoroughly cleaned by means of steel brushes.

(e) Fitting -up of Pipes - In butt joints the root opening between the pipes shall be such as will ensure full penetration without burn-through in accordance with the approved welding procedure. When aligning pipes, the offset between pipe ends about to be joined shall be reduced to a minimum. External line-up clamps shall be used to centre pipes. Internal clamps may be used when approved by the Engineer.

The external line-up clamp may be removed only after 50% of the root bead has already been welded, in segments equally distributed around the pipe, not shorter than 7 cm each; their quality and thickness shall not be inferior to those required for root welding. The internal clamp may be removed only after the whole of the root bead has been welded.

In lap joints the plain end of one pipe shall be shoved in until it abuts against the shoulder of the bell, so that the gap between the mortar lining of the two pipes is reduced to a minimum.

(f) Welding Positions - The welds shall be made either by roll welding or position welding. Roll welding will be permitted, provided alignment is maintained by the use of skids and roller dollies supporting two or more lengths of pipe. Position welding shall be done with the pipes resting on skids at the proper height over or alongside the trench, so as to permit the completion of the weld on the whole circumference. All requirements as to the quality of the welds shall apply equally to roll welding and position welding.

(g) Jointing of Line Sections - Pipes shall be connected to each other by welding as specified above, while they are placed on suitable supports on the trench bottom or on the ground beside the trench.

The length of sections to be welded together before lowering them into the trench shall be as directed by the Engineer. The position of every pipe or elbow in the section shall be such that, when the section has been lowered to the trench bottom the longitudinal seams will be located between the figures 10 and 2 on the clock face, so that repairs on the seams can be done in the trench without necessitating deep excavation.

Before being connected to the line, the inside of each pipe and each elbow shall be cleaned.

(h) Welding Mortar-lined Pipes - When butt-welding mortar-lined pipes, the Contractor shall take steps to ensure the continuity of the lining at the joints. The materials and methods employed to this end shall be as recommended by the manufacturers of the pipes, and approved by the Engineer or as directed by the Engineer. The cost of all materials and work required to ensure the continuity of the cement-mortar lining shall be deemed to be included in the unit rates for supply, laying and jointing of the pipes and shall not be paid for separately.

In pipes with lap joints which are not accessible from the inside, a sufficient quantity of mortar shall be placed in the bell just before the new pipe is shoved in. After the new pipe is laid in place, excessive mortar shall be removed and the inside of the joint finished by pulling a rubber ball or equivalent through the joint. Where the inside of the pipe is accessible, the mortar lining at the joint shall be completed by plastering on with a good bond to the existing lining and trowelling smooth and flush with the adjacent mortar lining. The mortar employed as specified above shall conform in all respects to requirements of Subsection 217.4.9 of this Specification.

(i) Repair of Weld Defects - The Engineer may permit repairs of defects in the root or filler beads to be made, but any weld that shows evidence of repair work having been done without such permission may be rejected. Pinholes and undercuts in the final bead may be repaired but such repairs shall be subject to the Engineer's approval. Undercuts not exceeding 1.0 mm in depth will not be considered as defects.

Before repairs are made, the defective areas shall be removed by chipping, grinding, or flame gouging. Any slag and scale shall be removed by wire brushing. When cracks are found, the entire seam shall be cut away and rewelded.

The Contractor shall clearly mark with oil paint on top of the pipe any defect that has been discovered in the pipe or weld.

217.4.7 Miscellaneous Welding Works

(a) Cutting and Preparing Pipes for Welding - The plane of square cuts shall be perpendicular to the pipe axis. Oblique cuts shall be accurately made to the required angle and in such a manner that the cut edge is in one plane. Pipe ends for butt welding shall be bevelled to an angle of 30^{o} with the plane of the edge, with a permissible deviation of 0^{o} to $+5^{o}$. All cutting shall be done by mechanical tools, or by acetylene flame-cutting by means of a special cutting device or by Arc-air (carbon electrode with air jet). Flame cut surfaces shall be perfectly clean, and where necessary, the cut surfaces shall be filed smooth. Mortar-lined pipes shall always be cut by Arc-air cutting equipment. After the metal has been cut through to the mortar lining, the latter shall be carefully broken along the cut and the pipe edge prepared for welding as required above.

(b) Welding of Flanges - The welding of flanges to pipes shall be of the same quality as that specified for pipe welds. Slip-on flanges shall receive an interior weld inside the flange opening, in addition to the external weld. Weld-neck flanges shall be attached to pipe ends as specified above for the welding together of pipes, care being taken to ensure a perfect concentric alignment between pipe and flange.

Flanges shall be welded to pipes very carefully, so that the faces of the flanges shall be truly perpendicular to the pipe axes. Flange faces shall be kept free from weld material or other defects such as splutter, dirt, etc. All defects in flange faces that may interfere with the proper sealing of flanges shall be repaired.

(c) Fabricated Fittings - Where shown on the Drawings or where directed by the Engineer, fabricated fittings, specials, etc., as specified hereafter, will be used instead of factory-made fittings.

Welded elbows shall consist of suitable obliquely cut pieces of pipe ("mitres") welded together. The mitres shall be cut to the exact dimensions shown on the Drawings and accurately fitted together so that after welding the completed elbow will have the exact shape and dimensions shown on the Drawings. The ends of mitres shall be bevelled for welding as specified above. In all elbows of 12" (300 mm) diameter and larger the seams between mitres shall also receive an internal weld pass which shall be made after the weld root has been thoroughly cleaned.

Fabricated T and Y branch connections shall be produced by cutting the branch pipe to the correct intersection fitting the curvature of the main pipe, cutting the required opening in the main pipe and welding the branch to the main pipe. Where shown on the Drawings or instructed by the Engineer the fabricated T and Y branches shall be reinforced by welded saddles. The saddle shall be cut and bent to the required shape and slipped over the branch, its outside edges shall be welded to the main pipe while the edge of its opening shall be welded to the branch pipe.

The quality of welds shall be as specified for pipe connections. The inside of the pipe intersection shall be cleaned and smoothed to ensure unobstructed flow in the pipe.

Pipe reducers shall be fabricated from steel plate properly cut, rolled and welded or by cutting out wedge-shaped pieces from a length of pipe the diameter of which shall be equal to the larger diameter of the required reducer, squeezing the pipe together to the shape of the reducer and welding along the cut edges, which shall be straight and bevelled for welding, the gap between them being of uniform width over the whole length. On reducers of 12" (300 mm) diameter and larger an internal pass shall be added to each weld, which shall not protrude more than 1.5 mm into the inside of the pipe. The end planes of the reducer shall be parallel to each other and truly perpendicular to the pipe axis and shall be bevelled for butt welding.

In all fabricated fittings, the quality of welds shall be as specified for welded pipe connections and the insides of intersections shall be cleaned and smoothed to ensure unobstructed flow in the pipe.

(d) Prefabricated Fittings - Prefabricated elbows, tees and reducers shall be jointed to pipes by square butt welds or by lap welds or by flanges, all as specified above for pipe-welding, care being taken that the true alignment and correct position of the fitting are ensured.

217.4.8 Installation of Valves and Fittings

(a) General - Before being installed, valves, fittings, and especially valve seats, shall be cleaned of any dirt. The correct positioning of valves shall be ensured by means of a spirit level. Flanges shall be welded to the pipes in accordance with the requirements of Subsection 217.4.7 (b) above.

Fitting the valves to pipes shall be done accurately, but without using force. Fitting of valves by tightening bolts forcibly or by any other method that may cause internal stresses in valves or flanges will not be permitted.

(b) Bolts - Only bolts of the correct diameter shall be used. All bolts used on a valve shall be of equal length, which shall be such that after the nut has been tightened not less than one thread and not more than three threads of the bolt will protrude from the nut. Bolts shall be tightened crosswise, gradually and uniformly.

(c) Gaskets - Only one sealing gasket shall be used between each pair of flanges. Gaskets shall be of the ring type, i.e. their outer rim shall just touch the bolt holes and their inside diameter shall be equal to that of the corresponding pipe.

Gasket material shall be either fabric reinforced rubber or compressed asbestos sheets of a type and make approved by the Engineer. Gaskets shall be fabricated by cutting from sheets. Cutting gaskets by hammering on the flange will be strictly prohibited. When being installed, the gaskets shall be absolutely clean. Each gasket shall be used only once.

(d) Gate Valves - Before installation, each valve shall be fully opened and cleaned on the inside with a clean rag soaked in kerosene. Then the valve shall be completely closed and the flange faces also cleaned with kerosene. After cleaning, the flange faces shall be protected with wooden or cardboard covers, which may be removed only just prior to installation of the valve.

(e) Butterfly Valves shall be installed between companion flanges welded to the pipe ends, in accordance with manufacturer's instructions.

(f) Mechanical Couplings shall be of the "Dresser", "Viking-Johnson" or "Victaulic" type, as shown on the Drawings. Ends of pipes to be jointed by Victaulic couplings shall be fitted with accurately machined rings. Ends of pipes to be jointed by Dresser couplings shall be clean of paint, coating or other foreign matter and shall be sufficiently round for at least 20 cm from the pipe edge so that joint rings and couplings shall slide freely onto pipes; no forcing on rings by hammer blows will be permitted. All joint components and pipe ends shall be cleaned and inspected before installation of joint. Rubber gaskets shall be kept in a clean and dry place and protected against sunshine until immediately before installation. Coupling bolts shall be tightened evenly and gradually with sufficient force to attain a tight joint but without causing undue stresses in bolts or joint components. All mechanical coupling shall be bonded and bridged for electrical continuity.

217.4.9 Lining, Coating and Painting of Pipes

(a) General - Where noted on the Drawings, and/or required in the Specification or Bill of Quantities and/or directed by the Engineer, steel pipes, fittings and specials shall be protected against corrosion by internal linings or external coatings or by both internal linings and external coatings. Internal protection shall be provided by cement-mortar, or bitumen linings. External protection shall be provided by reinforced bitumen, or point coatings. Other types of linings and coatings may be required in the Particular Specification.

(b) Cement-Mortar Lining -Where required, steel pipes, fittings and specials shall be internally cement-mortar lined in accordance with the provisions of B.S. 534. Cement-mortar lining for specials and short unlined pipe sections, and repairs to damaged existing lining shall be carried out by hand, to the approval of the Engineer.

Where hand applied lining is approved by the Engineer, the materials, the preparation and the application of the cement-mortar shall conform in all respects to B.S. 534. The mixing of mortar shall be done in a suitable mechanical mixer until a homogeneous mixture of uniform colour and of the required consistency is obtained. The quantity of mortar prepared at a time shall not exceed that required for a half an hour's work.

The steel surfaces to be lined with cement-mortar shall be cleaned thoroughly from dirt, oil, grease, traces of paint or mortar, slag, heavy rust and mill scale. Light rust adhering to the steel surface can be left. Immediately before applying mortar, the steel surface shall be wetted.

Cement-mortar shall be applied to the inter surface of the pipe or special by a steel trowel to the thicknesses specified in B.S. 534. The cement-mortar lining shall be given a smooth surface with a steel trowel and shall be finished off flush with the ends of the pipe or special. Curing compound shall be applied to the lining immediately after its completion to prevent its rapid drying.

The cement-mortar lining at pipe ends shall be of full thickness and shall end flush with the pipe edge. Small defects and depressions not exceeding 1.5 mm in depth are permissible, provided that their aggregate length does not exceed half the pipe circumference. When larger defects or cracks are found in the lining, the pipe will be rejected unless the Engineer permits repair of the lining or cutting away of the defective sections of the pipes. To repair defects in the cement-mortar lining, the defective portion of lining shall be removed to sound and undisturbed mortar, the metal shall be cleaned and new cement-mortar shall be applied as specified. The thickness of the new lining shall be equal to that of the existing lining and shall be finished smooth and flush with it. The mortar of the repair shall be well bonded to the pipe metal and to the existing lining.

(c) Bitumen Lining - Where required, steel pipes, fittings and specials shall be internally bitumen-lined in accordance with B.S. 534 and B.S. 4147.

(d) Bitumen Coating on Underground Piping - Underground steel pipes shall be externally protected by a fiberglass reinforced bitumen coating, in accordance with B.S. 534, B.S. 3415 and B.S. 4147.

The coating will be of the Single Wrap or Double Wrap, or Multiple Wrap type as indicated on the Drawings or in the Particular Specification. Pipe ends to be welded shall be bare. All valves, fittings and pipe to be laid below ground and which have not been factory-coated shall be supplied with an anticorrosive priming and receive a bitumen coating in-situ.

The Contractor's work under this Subsection shall include coating of weld joints; the repair of defects in factory-applied coating and the coating of primed or bare pipes, fittings and valves.

In-situ coating applied by the Contractor shall be equal in all respects to factory-made coatings. Repairs, coating of welds on coated pipes and the coating of bare pipes and fittings shall be bonded to the existing pipe coating so that a continuous uninterrupted coating over the entire length of pipeline is achieved. No joint shall be coated before the Engineer's approval to proceed with coating has been given.

After all joints, bare sections, valves and fittings and defects in coating have been coated and repaired as specified and before lowering the coated steel pipe into the trench, the continuity and integrity of the coating shall be tested by means of an electric Holiday detector, in accordance with A.W.W.A. Specification C203-62 Section 3.13, in application to a single bitumen coat. Test voltages for multiple coats shall be specified by the Engineer.

All defects in coating shall be repaired and retested.

(e) Painting of Exposed Piping - The metal surfaces of all pipes laid above ground together with valves, straps and supports as well as all steel structures shall be painted as specified in Subsection 207.1.7 of this Specification.

The outside surface of coated bitumen pipes shall be given a coat of water-resistant whitewash to protect the bitumen from sunlight and overheating.

217.4.10 Laying of Steel Pipelines

Steel pipes shall be laid underground in trenches, or above ground on supports, or built-in in earth or concrete works, as shown on Drawings or directed by the Engineer. All joints between pipes and between pipes and fittings shall be done by welding or by flanges or by mechanical joints, as shown on Drawings or as directed by the Engineer.

Before lowering in, the pipe coating shall be inspected and all defects repaired. Lowering the pipes into the trench shall be done by pipelayers or other equipment acceptable to the Engineer, so that no damage or deformation is caused to the pipes or the coating and lining. Welded pipes shall be laid on the finished trench bottom, so that each pipe is supported over its entire length.

Where valves, or flanges or mechanical joints are to be installed, or overhead welds are to be made in the trench, the latter shall be widened and deepened by additional excavation around the pipe in order to provide working space (bell holes). Before joining each pipe to the line a cleaning swab with a cable attached to it shall be introduced into the pipe last welded before the new pipe. When the welding to the line has been completed the swab shall be pulled forward by means of the cable through the new pipe, thus cleaning and removing all slag, metal, dirt and foreign matter which may have accumulated inside the pipe. Where pipes are large enough to be entered by workmen, the said cleaning shall be done by hand.

At the end of each working day and whenever work is discontinued for a considerable time, the ends of each welded section whether in or alongside the trench shall be closed by a suitable cover snapping onto the pipe end.
Lowering-in of pipes or placing them on permanent supports shall be done carefully to prevent damage to pipe coating or paint. To prevent pipes from slipping out of mechanical joints or excessive stresses building up in welds as a result of temperature changes, lowering-in of pipes and joining of sections shall be carried out in the early morning only.

The first stage backfill of the trench shall be done before the final tie-in welds or bolted connections (in the case of mechanical joints or flanges) are made, leaving a stretch of about 20 m uncovered on either side of such final joint.

217.4.11 Weld Inspection and Tests

(a) General - The Engineer will exercise a continuous control of the welding work and will inspect the quality of the welds. In addition to routine supervision and visual inspection of the completed welds, the Engineer will have the right to request samples to be cut out from welds for destructive tests and to order the welds to be tested by radiography.

(b) Destructive Tests - Destructive tests shall include all or some of the following, at the discretion of the Engineer:

- Break Test
- Bend Test
- Tensile Test (in special cases only)

Both the Contractor and the Engineer will endeavour to ensure the proper execution of welds, so as to avoid altogether or minimize the number of destructive tests.

Should one of the samples taken for the destructive tests fail to meet the standards of acceptability set out below, the Contractor will be required to cut additional samples from the same weld or from other welds made by the same welder. If any of the new samples fails to meet the requirements, the Contractor will cut more samples for testing until a clear picture of the extent of defective welds is obtained.

Should such additional tests show that the quality of the welds is unacceptable, as determined by the Engineer, the Engineer may require the Contractor to remove and reweld all welds made by the welder concerned.

Unless otherwise specified, the cost of cutting the sample and preparing and testing the specimens, and that of patching the pipe where the sample has been cut out, as well as the cost of all additional tests that may be required to determine the extent of defective welds as aforesaid, shall be borne by the Contractor and deemed to be included in the various unit rates.

Samples for Bending, Breaking and Tensile Tests shall be cut out from the pipe in the form of strips 5 cm wide, perpendicular to the weld seam and extending 10 cm on either side of the weld, so that the weld will be located in the centre of the sample. The opening resulting from cutting the sample shall be closed by welding on a patch of steel plate having a thickness not less than that of the pipe wall. The cost of patching up openings as herein described shall be included in the cost of taking samples as specified above.

The bend test samples shall be bent in a suitable jig in the field or in the shop. The bend shall be located exactly over the weld with the weld face on the convex side. The sample shall be considered to have met the requirements if it does not break and no cracks larger than 3 mm in any direction appear on the convex side of the bend.

The break test samples shall be hacksaw-notched on both edges across the centre of the weld to ensure breaking of the sample in the weld. The sample shall be supported on both sides of the weld and broken by a strong hammer blow. For the weld to be acceptable, the broken surface shall show full penetration of the weld and no burns or excessive slag inclusions. The breaked surface shall show no more than one gas pocket per square centimeter, provided that no gas pocket has a diameter larger than 1.5 mm.

Samples for tensile strength and elongation tests shall be sent for testing to an authorized laboratory. These tests will serve as a control of the welding procedure and of the quality of the electrodes, but not to test the welder’s ability. In this test the

samples shall show a tensile strength not less than that required of the steel of which the pipes are made.

(c) Radiographic Tests - Where required, radiographic tests shall be performed in accordance with B.S. 2910. Unless otherwise specified, 10 (ten) percent of all weld seams shall be radiographed. If these primary tests should not give satisfactory results, the Engineer will conduct additional radiographic tests to ascertain the quality of the welding work. All weld defects discovered by the tests shall be repaired as directed by the Engineer and all repaired welds shall be retested.

The cost of the routine radiographic test (10 percent), as well as any additional tests which the Engineer may think it necessary to conduct because of the defective quality of the welds, shall be borne by the Contractor and deemed to be included in the various unit rates. The Contractor shall also bear the cost of repair of all welds found defective under test as well as the cost of retesting such repaired welds.

217.4.12 Hydrostatic Pressure Test

After pipelaying, casting of concrete structures on the line and partial backfill have been completed, the pipeline shall be subjected to a hydrostatic pressure test. The line shall be tested over its entire length or, in the case of long lines, in sections, as approved by the Engineer. Pressure tests shall be performed only in the presence of the Engineer.

The magnitude of the test pressure, the testing procedure and all other requirements shall be as described in Subsection 217.3.10 (b) of this Specification, except that the Hydrostatic Pressure Test can commence 24 hours after the completion of filling, if permitted by the Engineer.

217.4.13 Methods of Measurement and Payment

Steel pipes shall be classified for payment according to type of joint, diameter and nominal pressure, and shall be measured in linear meters of completed pipeline in place measured along the crown of the pipeline. The length measured for payment shall include the lengths of all fittings, valves and specials installed in the line.

Price for fittings, bends, junctions, specials, detachable joints, flanges (where not an integral part of pipe or fitting), etc., shall be considered as included in the cost of pipes, unless otherwise specified in the particular specifications on the B.O.Q..

Payment for steel pipes and for fittings, specials etc... shall include:

– Supply, hauling, handling, unloading and stacking of pipes and fittings including all necessary jointing materials, electrodes, gaskets, nuts and bolts etc. for pipes and fittings and factory coating and lining up of all pipes and fittings.

– Removal from stacks; hauling and stringing alongside trench; laying and jointing of pipes and fittings by welding (including square and mitred welds, both in and above trench) and/or mechanical joints; field coating and lining of joints and of pipes and fittings where required and all repairs to factory coatings and linings, including supply of all necessary materials; inspection and testing of coating, weld inspections and welders' qualification tests; and final cleaning and flushing of pipeline. The unit

rates for this item, for each type, wall thickness and diameter of pipe and fitting, shall be the same for all depths of trench in which the pipes and fittings are to be installed.

Only pipes, fittings, junctions, bends etc. actually laid in trench and tested and accepted by the Engineer shall be measured for payment under the above items, and no allowance whatsoever will be made for any waste, loss, etc.

Excavation and backfill, special beddings, surrounds and manholes and chambers shall be paid for under separate items in the Bill of Quantities, unless otherwise noted.

a) Testing of completed pipeline - the cost of carrying out hydrostatic pressure test, as specified, shall be paid for under a separate item in the Bill of Quantities, by linear meters of pipe tested.

b) Valve Assemblies for which items have been included in the Bill of Quantities shall be classified according to their diameter and measured for payment by the number of complete units as described.

   The unit rate for a valve assembly shall include for: the supply of the valves complete with counter-flanges and accessories; supply of gaskets, bolts and nuts, all welding electrodes, paints and coating materials; cleaning and complete installation of the assemblies, inclusive of all cuts and welds; fitting up of flanges and fittings, placing them in their exact position and completing the joints, inclusive of tightening of bolts and anchors; bridging of mechanical joints; making good of paint and coating and sealing off pipes passing through chamber walls.

c) Pipe Assemblies that are described as such in the Bill of Quantities shall, for purposes of payment, be measured by the number of complete units within the limits shown in the Drawings and/or defined in the relevant items of the Bill of Quantities.

   The price of each assembly shall include for the necessary excavation and backfill; supply of all pipes, accessories, joints, valves, supports and all other parts of the assembly; cutting, fitting, welding, jointing and installation of pipes in position; fixing of supports for pipes; internal and/or external coating as required; testing of welds; pressure tests of the assembly and all other works required for the fitting of the completed assembly between the limiting points.

d) Various Welding and Installation Works - In case of measurement of welding and installation works - whether as separate items in the Bill of Quantities or for the purpose of varying any of the rates for complete assemblies under Subsection (d) and (e), or if the Engineer should deem such separate measurement necessary for any other reason - such works shall be measured and paid for as provided in the following paragraphs (1) and (5).

   The necessity for such measurement will in each case be determined by the Engineer. Measurement will be by number, classified by type and size as detailed in the Bill of Quantities. The unit rates shall include everything as detailed below and in addition also the supply of all materials and all additional excavation necessary for installation.

1) <u>Square and Mitre Welds:</u> The unit rates shall include for the necessary cutting, bevelling, fitting-up and welding of pipes as specified.

2) Welding of Tee, Y and Weld-O-Let Outlets: The unit rates shall include for cutting, shaping, bevelling, and welding the outlet pipe to the main pipe, as well as for cutting the opening in the main pipe.

3) Welding Flanges: The unit rate shall include for squaring the pipe end as required, welding-on the flange to the pipe at right angles to the pipe axis and for both the external and the internal welds. Welding of weld-neck flanges will be considered as a square weld under (1).

4) Fabrication of Pipe Reducers: The unit rate for fabricating a pipe reducer shall include for cutting the pipe to required length, cutting out wedges in the pipe wall, tapering the reducer to the correct shape and welding the longitudinal seams.

5) Making of Flanged Connection and Mechanical Joints and Installation of Valves and Fittings: The work shall include cleaning and fitting-up of flanges, joints, valves, etc., installation of joint rings, gaskets etc.; insertion and tightening up of bolts, nuts and washers; and welding on of anchor lugs and installing of threaded rods in anchored "Dresser" couplings, where required.

   The cost of the work described in Paragraphs (1)-(5) above shall be deemed to be included in the various items of supply, laying and jointing of steel pipes and fittings and shall not be paid for separately.

e) Inserting of Line Pipe in Casing shall be measured, separately for each diameter of line pipe, in linear meters by the length of the casings and shall be paid as an extra over the price for pipelaying. The unit rate inserted in the Bill(s) of Quantities for inserting line pipes in casing shall be deemed to cover the cost of the supply and hauling of casing pipe, welding of casing pipe sections, supply and spacing of spacers, coating of casing pipe where practicable, installing line pipe in casing and sealing of openings at both ends of casing pipe.

217.5 CAST IRON AND DUCTILE IRON PIPES AND FITTINGS

217.5.1 Quality Requirements

All cast iron and ductile iron pipes and fittings to be supplied under this Specification shall be obtained from approved manufacturers. They shall be of the class and shall have joint ends as shown on the Drawings or as specified and shall otherwise comply in all respects with B.S. 4622 - Grey Iron Pipes and Fittings, and B.S. 4772 - Ductile Iron Pipes and Fittings.

– External Coating: pipes and fittings shall be given an external coating of zinc in accordance with ISO 8179 or BS 4772 and a finishing coating of either cold applied bitumen complying with the performance requirements of BS 3416 Type II material, or hot applied bitumen to BS 4147 Type I Grade C.

– Internal Lining: All pipes and fittings shall be lined internally with cement motar and shall comply with ISO 4179 or BS 4772. The inside of the sockets shall be coated with bitumen as used for the finishing coating to the pipes.

While the pipes are still suspended over the trench before lowering or before mounting, they shall be inspected for defects and rung with a light hammer to detect cracks. Defective pipes shall be dismounted, removed from the site and replaced by flawless pipes. Only pipes inspected and accepted on the site by the Engineer shall be incorporated into the works.

217.5.2 Hauling and Handling of Pipes

The Contractor shall check each pipe before loading and shall reject all damaged or defective pipes. The Contractor shall load and properly secure the pipes on the vehicles and take all necessary measures to prevent any damage to the pipes during transport. The Contractor shall be responsible for the quality of the pipes and for their condition upon and after delivery to the site, and shall immediately remove from the site any damaged or defective pipes and replace them at his own expense.

No pipes or fittings shall be allowed to drop, roll freely or strike objects which are likely to damage them. Special care shall be taken not to spoil the tar or bitumen coating.

217.5.3 Laying and Jointing

(a) Laying - Before C.I. or Ductile pipes are laid, all dirt and foreign matter shall be removed from inside and all lumps blisters, excess coal tar, oil, grease and moisture shall be eliminated from the surfaces of the joints. After the pipe is laid and mounted, care shall be taken to avoid entrance of dirt, water and foreign matter from the trench or from elsewhere by the use of tight bulkheads.

(b) Jointing of cast iron pipes and fittings - Joints shall be flanged; or mechanical joints; or rubber gasket “push-in” flexible joints, all as specified and/or shown on Drawings.

(c) Jointing of ductile iron pipes and fittings - Joints in ductile iron pipes and fittings shall be of one of the following types according to the Drawing and the Particular Specification:

- Spigot and socket joint with rubber gasket
- Flanged joints
- Mechanical joints

All joints shall conform to B.S. 4772.

217.5.4 Testing

Testing instructions and requirements for Cast Iron and Ductile Iron pipelines shall be as specified in Subsection 217.4.12 for steel pipelines.

217.5.5 Methods of Measurement and Payment

Cast Iron pipes and Ductile Iron pipes and fittings shall be classified for payment according to type, diameter and class and shall be measured in linear meters of completed pipeline in place, measured along the crown of the pipeline. The length measured for payment shall include the lengths of all fittings, valves and specials installed in the line.

The price for fittings, bends, junctions, specials, detachable joints, flanges (when not integral part of pipe or fitting) etc. shall be considered as included in the cost of pipes, unless otherwise specified in the particular specifications or the B.O.Q.

Alternatively, if so stated in the Particular Specification and/or in the Bill of Quantities, C.I. and Ductile Iron pipes and fittings may be measured by number of pipes of defined net lengths and by number of fittings.

The payment for C.I. and Ductile Iron pipes and (under separate items) for fittings, bends, junctions etc. shall include:

– Supply, hauling, unloading and stacking of pipes and fittings including all necessary joints and jointing materials.

– Removal from stacks, hauling and stringing alongside the trench, laying and jointing of pipes and fittings at any depth of trench, connections to manholes and/or chambers and final cleaning and flushing of pipeline. The unit rates for this item for each type, class and diameter of pipe and fitting shall be the same for all depths of trench in which the pipes and fittings are to be installed.

– Testing of completed pipeline
  - For pressure and gravity pipelines shall be paid for under a separate item in the Bill of Quantities, by linear meters of pipe tested.

Only pipes, fittings, junctions, bends etc. actually laid, jointed and tested and accepted by the Engineer shall be taken into account for payment under items and no allowance whatsoever will be made for any breakage, loss, etc.
Excavation and backfill, special beddings, surrounds and manholes and chambers shall be paid for under separate items in the Bill of Quantities, unless otherwise noted.

217.6 G.R.P. PIPES

217.6.1 Quality Requirements

a- Manufacturers Pre-qualification

GRP pipes and fittings shall be manufactured by an established pipe Manufacturer in a purpose-built facility for the production of such materials. The Manufacturer shall have at least 5 years experience at the facility in the production of the full range of pipe diameters (25 - 3000 mm) pipe, fittings and related products. Evidence of previous experience shall be presented. The Manufacturer shall have an approved Quality Management System complying with ISO 9001 which shall cover all activities being undertaken during the manufacturing, supervision and installation of the subject pipe systems.

b- Applicable Codes and Standards

The following internationally accepted standards are the minimum requirements for the manufacture of GRP Pipe Systems and should be referenced throughout the Project Specification where appropriate.

AWWA C950	Glass Fiber Reinforced Thermosetting Resin Pressure (Latest Edition).
ASTM D3262	“Fiberglass” (Glass - Fiber - Reinforced Thermosetting - Resin) Gravity Sewer pipe.

BS 5480	Glass reinforced plastics (GRP) pipes, joints and fittings for use for water supply or sewerage.
ASTM D3517	Specification for Glass Fiber Reinforced thermosetting resin pressure pipe.
ASTM D3754	Specification for GRP sewer and industrial pressure pipe.

c- Product Description

c.1- General

The GRP pipe shall consist of a corrosion resistant liner, a structural wall and a resin rich exterior layer. The resin to be used is of the Isophtalic type.

Liner
Pipe and Fittings shall have a resin rich liner consisting of a 0.25mm thick resin rich layer and "C" glass backed by a 0.75mm thick layer with a resin glass ratio of 70:30.

Structural Wall
The pipe structural wall shall be as specified in AWWA C950-01 Sec. 4.3 cell classification system with the resin systems to be the appropriate grade of Isophtalic as required by the system type and operating conditions.

External Layer
Pipe shall have a 0.01" (0.30mm) thick resin rich exterior surface impregnated with Isophtalic resin as required by the system type and operating conditions.

c.2- Materials

- Glass Reinforcements shall be compatible with the impregnating resin used.
- Resins used shall be a commercial high grade thermosetting Isophtalic type as specified under Section c.1 above.
- No dark pigments shall be used in the GRP pipe or joints. No additives shall be used except when required for viscosity control.
- Aggregates and Fillers use shall be limited to 30% maximum for any Pressure Application. Care should be taken to ensure no aggregate becomes embedded in the resin rich liners.
- All GRP pipes and fittings conveying potable water shall be certified and listed for potable water use by internationally recognized independent water authority such as the Water Research Council "WRc", the DVGW, KIWA, Lyonnaises Des Eaux, or NSF etc..

d- Requirements

d.1- Wall Thickness
GRP pipe systems up to and including 2000 mm diameter shall be of the solid wall type. The wall thickness required for each size/pressure and stiffness class shall be established by the Manufacturer to meet the design requirements but in no case shall wall thickness be less than (0.010 x ND); where ND is the nominal pipe inside diameter. The pipe working pressure class shall be based on the Hydrostatic design basis (HDB) of the pipe with a design (service) factor of 0.5.

d.2- Length
GRP (Standard = 6 or 12 Meters) pipe shall be manufactured in standard laying lengths of not greater than 12 meters. Random short lengths, if supplied, shall not exceed 5% of the quantity supplied of each size. The tolerance on the Manufacturer's declared laying length shall not exceed ± 25 mm.

d.3- Diameters
Pipe shall be manufactured in standard metric sizes based on the pipe nominal inside diameter in sizes 25mm and larger. The actual inside diameter shall not vary from the nominal inside diameter by more than 1.5% or 4 mm whichever is greater.

d.4- Stiffness
The pipe stiffness shall be determined by the Manufacturer to meet the design requirement with particular regard to installation method, burial depths, deflection limits, buckling and vacuum requirements, in accordance with AWWA M45. However, stiffness shall be at least 5000 N/m^2 or as stated in the drawings or in the particular specifications.

d.7- Joints
Standard buried pipe with unrestrained joints shall be filament wound GRP coupling, with two rubber ring gaskets. Rubber rings shall be suitable for the intended application. Joints shall allow for at least 0.75 degree deviation while remaining water tight at 1.5 times the pipe operating pressure. The rubber rings shall be the sole element depended upon for water tightness. This system will require thrust blocks at changes in direction to accommodate thrust loads.

d.8- Workmanship

- GRP pipe, fittings and joints shall be free from de-laminations, cracks, bubbles, pinholes, pits, blisters, foreign inclusions and resin-starved areas that due to their nature, degree or extent detrimentally affect the strength and serviceability of the pipe. No glass fiber reinforcements shall penetrate the interior surface of the pipe wall.
- Joint sealing surfaces shall be free of dents, gouges, de-laminations, or other surface irregularities that will affect the integrity of the joints.
- GRP pipe, fittings and joints shall be as uniform as commercially practicable in color, capacity, density and other physical properties.

d.9- Fittings

- GRP fittings such as bends, tees, junctions and reducers shall be equal or superior in performance to the GRP pipe of the same diameter and pressure. All fittings shall be have a smooth internal surface with similar wall construction.
- For GRP fittings, the deviation from the stated value of the angle of change of direction of a bend, tee, junction etc. shall not exceed ± 1 degree.
- The tolerance on the Manufacturer's declared length of fitting shall be ± 10 mm taken from the point of intersection to the end of the fitting or ± 10 mm on a straight fittings.
- All GRP fittings shall be fabricated in the factory to ensure Quality Control (under no circumstance shall fabrication of fittings be allowed on site by Contractor). Complex fittings arrangements may be pre-assembled by the pipe Manufacturer in the factory such that field joints are kept to a minimum.

e- Design Parameters

Pipe shall meet the following minimum design requirements:

– Operating Pressure (Pw)	As specified; Min 1000 Kpa for Pressure pipes
– Surge Pressure (Ps)	40% of 'Pw' unless otherwise specified.
– Vacuum (Pc)	As specified.
– Minimum Earth Cover	1.0 m or as shown on drawings for buried pipe.
– Initial Installed Deflection for Buried pipe	2.0% Max.
– Long Term Installed Deflection for Buried Pipe	5.0% Max
– Safety factors	
Pressure Rating	>= 1.8
Ring Bending Strain (stress)	>= 1.5
Combined Strain (stress)	>= 1.5
Buckling	>= 2.5

The Contractor shall be responsible for implementing / installing the correct design for each GRP pipe system.

f- Inspection & Testing

f.1- The Manufacturer shall take adequate measures in the production of the GRP pipes and fittings covered by this specifications to assure compliance with the requirements herein. An Inspection and Testing Plan (ITP) should be established by the Manufacturer. Plant inspection by the Engineer and/or the Contractor's qualified personnel or the omission of such inspections shall not relieve the Manufacturer of

the responsibility to furnish products complying with the requirements of the minimum manufacturing requirements given herein.

f.2- Production and Testing Notice - When plant inspection is required by the Engineer or the Contractor, the Manufacturer shall provide adequate advance notice of when and where production and testing of ordered products will commence.

f.3- The Engineer and the Contractor shall have free access with reasonable advance notice to the Manufacturer's plant areas that are necessary to assure that products comply with all requirements herein.

f.4- As a minimum the following tests shall be performed at the indicated intervals unless otherwise agreed-upon, and shall form a part of the Manufacturers overall quality control program.

The following tests shall be conducted on every pipe;
- Visual Inspection, as per manufacturer standard
- Dimension Measurements, as per manufacturer standard
- Resin cure (Barcol Hardness), ASTM D2583
- Hydrostatic Pressure test for pipe up to 2000 mm in diameter, ASTM D3517

The following tests shall be conducted on pipe samples at a frequency of not less than one per 50 pipes (one lot) of the same Diameter and Pressure.
- Stiffness, ASTM D24313 or BS5480 App. H.
- Hoop Tensile Strength by split disc, ASTM D2290 or BS5480 App. C or D.
- Longitudinal Tensile Strength, ASTM D638 or BS5480 App. A
- Loss on ignition (composition), ASTM D2584

The Supplier shall submit to the consultant qualification test reports for the following test:
- HDB in accordance with ASTM D2992 procedure B or BS5480 App. E
- HDB reconfirmation in accordance with ASTM D2992 section 12
- Cyclic test
- Long term ring bending test in accordance with ASTM D5365-93
- Coupling tightness in accordance with ASTM D4161 or BS5480 App. M

The supplier shall give evidence that the GRP pipe produced in his own plant has successfully passed the above mentioned tests. All these tests should be conducted in the plant and witnessed by a third party. If so directed by the Engineer, the selection of samples and the tests shall be witnessed also by a representative of the Engineer, who shall be informed at least 48 hours in advance of any sampling or testing.

Test methods shall be in accordance with AWWA C950-01 and BS 5480 or other relevant standards. Copies of all test reports shall be submitted to the Engineer for each lot delivered to Site.

The cost of samples, their transportation to the laboratory and their testing shall be deemed to be included in the unit rates and shall not be paid for separately.

f.5- Pipe Data Sheet should be as follows:

Nominal Diameter (ND)		(mm)
Service (Specify) Underground / Aboveground		KPa
Rated Working Pressure		KPa
Allowable Vacuum		Kpa
Pipe Wall		
Nominal total thickness		mm
Inner Liner	Thickness	mm
	Resin Type	
	Glass Type	
Structural Wall	Thickness	mm
	Resin Type	
	Glass Type	
	(Aggregate type)	
Exterior Layer	Thickness	mm
Mechanical Properties		
Minimum initial specific stiffness STIS		N/M^2
Initial longitudinal tensile strength		KN/M^2
Initial Hoop tensile strength		KN/M^2

217.6.2 Hauling, Handling and Storage

GRP pipes shall be handled, stored and installed in strict accordance to the Manufacturer written instructions.

Rough handling of pipes shall at all times be avoided, pipes shall not be dropped or thrown on the ground. Severe impact with other pipes or object must be avoided. All pipes should be lifted at their mid-point. Pipes must not be lifted with chains, wire ropes etc, a suitable textile sling must be used.

During unloading the pipes, joints and specials must be carefully inspected to verify the following:

a) Products are not damaged
b) Joints are positioned correctly
c) Classification is as specified

Attention shall be paid to stack heights to avoid the possible deformation of the pipe diameter. No stacking of pipe larger than 1.8m in diameter shall be allowed on site or during transport.

217.6.3 Laying and Jointing

After the excavation and preparation of a section of pipe trench has been completed, it shall be inspected by the Engineer. Just before pipe laying, the trench shall be cleaned of all stones, soil and other debris that might have fallen therein.

All pipe laying shall be carried out by experienced pipe-layers, well skilled in this work.

The Contractor shall submit the pipe Manufacturer's Installation Manual and associated Data for Engineer review. A site meeting to include Engineer, Contractor and Manufacturer is to occur to clarify any outstanding issues / questions on the given installation procedures.

The pipe installation procedures and practices chosen shall meet the design requirements specified.

Immediately before being laid, each pipe and fittings shall be carefully examined both inside and outside for any damage, and all dust, dirt and foreign matter shall be removed. Care shall be taken to ensure that they remain clean during laying.

In order to prevent stones and soil from entering the pipe, a suitable cap or plug shall be provided with which the last pipe laid shall be closed when pipelaying is not actually in progress. The plug will be of the screw-up expanding type or of tapered wood.

Where bends are required, performed bends of the desired radius shall be used. Hot bending on site is not permitted.

All joints shall be flexible, with approved rubber rings. Rubber rings shall comply with B.S. EN681-1 (Elastomeric Joint Rings for Pipework and Pipelines) and shall be of the type designated on the Drawings, or in the Particular Specification, or as directed by the Engineer.

Prior to laying, the pipe and joint must be thoroughly inspected. Check for damage, joint position, pressure classification and cleanliness.

To ensure clean assembly and to prevent the weight of the pipe being taken on the joint, a hole should be excavated at the joint position prior to laying the pipe. When the joint has been made, fill and compact the hole with bedding material to provide continuous support to the pipe along its entire length.

Reinforced Concrete Thrust Blocks shall be used at all changes in direction, size reduction / expansion. Thrust blocks shall encase the entire GRP fitting at the directional change and should be constructed to fully absorb all thrust loads.

Pipe Deflection readings shall be taken and recorded on all buried pipe at two meter intervals. Initial deflections shall not show a reduction in internal vertical diameter for over 2.0 percent of the pipe ID.

For standard buried unrestrained pipeline sections, a flexibly jointed short pipe shall be incorporated outside rigid structures to provide pipeline flexibility against differential settlement. A minimum of two (2) flexible joints on either side of a rigid structure is required. The length of the short pipe shall be in accordance with the Manufacturers recommendation.

217.6.4 Testing

Testing instructions and requirements for GRP gravity pipelines shall be as specified in Subsection 217.2.6 for concrete pipelines. Testing instructions and requirements for GRP pressure pipelines shall be as specified in Subsection 217.3.10 (b) for A.C. pressure pipes, except that the Hydrostatic pressure test can commence 24 hours after the completion of filling if permitted by the Engineer.

217.6.5 Methods of Measurement and Payment

GRP pipes shall be classified for payment according to type, diameter and class and shall be measured in linear meters of completed pipeline in place, along the crown of the pipeline, as follows:

- In gravity flow lines: between internal surfaces of manholes or chambers.
- In pressure flow lines: between stations.

The length measured for payment shall include the length of all fittings, valves and specials installed in the line.

Payment for GRP pipes and for fittings; specials etc. shall include:

- Supply, hauling, handling, unloading and staking of pipes and fittings including all necessary GRP joints and jointing materials for pipes and all GRP joints and jointing materials for fittings, specials, valves, etc.

- Removal from stacks; hauling and stringing alongside trench; laying and jointing of pipes and fittings, at any depth of trench; connections to manholes and/or chambers and final cleaning and flushing of pipeline. The unit rates for this item, for each type, class and diameter of pipe and fitting, shall be the same for all depths of trench in which the pipes and fittings are to be installed.

- Testing of completed pipeline
  - For gravity pipelines: the cost of testing shall be included in the unit rates for pipes and shall not be paid for separately.
  - For pressure pipelines: the cost of testing shall be paid for under a separate item in the Bill of Quantities, by linear meters of pipe tested.

Only pipes, fittings, junctions, bends etc. actually laid in trench and tested and accepted by the Engineer can be measured for payment under the above items, and no allowance whatsoever will be made for any breakage, loss, waste, etc.

Excavation and backfill, special beddings, surrounds and manholes and chambers shall be paid for under separate items in the Bill of Quantities, unless otherwise stated.

217.7 P.V.C. PIPES

217.7.1 Quality Requirements

P.V.C. pipes and fittings shall comply in all respects with the following standards:

- B.S. 3506 Unplasticized P.V.C. pipes for industrial uses.
- EN1452 Outside Diameters and Pressure Ratings of Pipe of Plastics Materials.
- EN1329 Unplasticized P.V.C. Underground Drain Pipe and Fittings.
- EN1401 Unplasticized P.V.C. Pipe and Fittings for Gravity Sewers.

All pipes and fittings shall be supplied by approved manufacturers. Class of pipes shall be as stated in the Drawings or in the Particular Specification. The nominal length of pipes shall be not less than 6.0 m and not greater than 9.0 m.

P.V.C. pipes shall be factory tested and shall be subjected to Hydraulic and to Impact (Falling Weight) Tests. The number and selection of samples for testing, the test procedure and the requirements shall all be as specified in the relevant EN. If so directed by the Engineer, the selection of samples and the Tests shall be witnessed by a representative of the Engineer, who shall be informed at least 48 hours in advance of any sampling or testing.

The cost of samples, their transportation to the laboratory and their testing shall be deemed to be included in the unit rates and shall not be paid for separately.

217.7.2 Hauling, Handling and Storage

Rough handling of pipes shall at all times be avoided, especially at low temperatures. During storage and transport, rigid P.V.C. pipes shall have as near continuous support as possible at all times, and care shall be taken to avoid damage to pipe by sharp edged angle irons, exposed nail heads, etc.

For long term storage in average ambient temperature, attention shall be paid to stack heights to avoid the possible deformation of the pipe diameters. A maximum stack height of 1 meter is recommended. For temporary storage on site, care shall be taken to ensure that the ground is level and free from bricks, stones and sharp edges. At high temperatures, rigid P.V.C. pipes shall be kept in the shade during long term storage. P.V.C. pipes with spigot and socket shall be stacked with the sockets protruding in alternate layers. Pipes bent, deformed in any way or changed in colour shall be rejected and no payment whatsoever shall be made for such pipes.

While transporting, the pipes shall not overhang the vehicle by more than 0.6 m. Pipe loads shall not be stacked higher than 2.0 m.

Where pipes are transported one inside another, care shall be taken that:

(a) The pipes are clean and free from grit.

(b) Suitable covering be provided over the exposed ends of the pipes to prevent the entry of grit during transport.

(c) The pipes in the lower layers are not excessively loaded to such a degree as would cause damage or undue distortion.

217.7.3 Laying and Jointing

After the excavation and preparation of a section of pipe trench has been completed, it shall be inspected by the Engineer. Just before pipelaying the trench shall be cleaned of all stones, soil and other debris that might have fallen therein.

All pipelaying shall be carried out by experienced pipe-layers, well skilled in this work.

Immediately before being laid, each pipe and fittings shall be carefully examined both inside and outside for any damage, and all dust, dirt and foreign matter shall be removed. Care shall be taken to ensure that they remain clean during laying. The use of a badger will be ordered by the Engineer, if in his opinion, dirt is not being satisfactorily excluded. The badger, on a sound rope, is to remain within the bore of the pipe previously laid and jointed and it is to be drawn forward as the work proceeds throughout the whole length of the sewer. The badger is to be of soft material which will not damage the internal surface of the pipes.

In order to prevent stones and soil from entering the pipe, a suitable cap or plug shall be provided with which the last pipe laid shall be closed when pipelaying is not actually in progress. The plug will be of the screw-up expanding type or of tapered wood.

Where bends are required, performed bends of the desired radii shall be used. Hot bending on site is not permitted.

All joints shall be flexible, with approved rubber rings. Rubber rings shall comply with B.S. EN681-1 (Elastomeric Joint Rings for Pipework and Pipelines) and shall be of the type designated on the Drawings, or in the Particular Specification, or as directed by the Engineer.

Pipe lengths and fittings shall be supplied with a chamfer on the spigot end. Where pipes have to be cut to length, the pipe shall be cut square and a chamfer formed on the spigot end using a medium file. Any saw flushing shall be scraped off with a knife. The spigot and socket shall be free from mud or grit, and the ring correctly located in its groove. A lubricant approved by the Engineer shall be applied to the chamfered portion of the spigot before its insertion in the socket.

Flanges complying with B.S. 4504 (flanges and Bolting for Pipes, Valves and Fittings, metric units) shall be used for the jointing of P.V.C. pipes with steel pipes and for the connection of valves and other appurtenances. The joint shall be made by compression of a gasket or ring seal set in the face of the flange.

Pipes shall be laid true to line by means of a line stretched along the sides of the pipes and true to level by means of a straight edge of suitable length kept inside the pipes and pulled forward to pegs boned in at suitable intervals between sight rails set to the proper levels.

217.7.4 Testing

Testing instructions and requirements for P.V.C. gravity pipelines shall be as specified in Subsection 217.2.6 for concrete pipelines except that the leakage under test shall not exceed 0.08 litre/m2 of internal wall pipe area/hour. Testing instructions and requirements for P.V.C. pressure pipelines shall be as specified in Subsection 217.3.10(b) for A.C. pressure pipes, except that the Hydrostatic pressure test can commence 24 hours after the completion of filing if permitted by the Engineer.

217.7.5 Methods of Measurements and Payment

P.V.C. pipes shall be classified for payment according to type, diameter and class and shall be measured in linear meters of completed pipeline in place, along the crown of the pipeline, as follows:

- In gravity flow lines: between internal surfaces of manholes or chambers.
- In pressure flow lines: between stations.

The length measured for payment shall include the length of all fittings, valves and specials installed in the line.

The price for fittings, specials, junctions, bends, detachable joints, valves, etc., shall be classified for payment according to type, diameter and class; shall be considered as included in the cost of pipes, unless otherwise specified in the particular specifications or the B.O.Q.

Alternatively, if so stated in the Particular Specification and/or in the Bill of Quantities, pipe and fittings may be measured by number of pipes of defined net lengths and by number of fittings.

Payment for P.V.C. pipes and for fittings; specials etc. shall include:

- Supply, hauling, unloading and staking of pipes and fittings including all necessary P.V.C. joints and jointing materials for pipes and all P.V.C. joints and jointing materials for fittings, specials, valves, etc.

- Removal from stacks, hauling and stringing alongside the trench, laying and jointing of pipes and fittings at any depth of trench, connections to manholes and/or chambers and final cleaning and flushing of pipeline. The unit rates for this item for each type, class and diameter of pipe and fitting shall be the same for all depths of trench in which the pipes and fittings are to be installed.

- Testing of completed pipeline

  - For gravity pipelines: the cost of testing shall be included in the unit rates for pipes and shall not be paid for separately.

  - For pressure pipelines: the cost of testing shall be paid for under a separate item in the Bill of Quantities, by linear meters of pipe tested.

Only pipes, fittings, junctions, bends etc. actually laid, in trench and tested and accepted by the Engineer shall be measured for payment under the above items, and no allowance whatsoever will be made for any breakage, loss, waste, etc.

Excavation and backfill, special beddings, surrounds and manholes and chambers shall be paid for under separate items in the Bill of Quantities, unless otherwise noted.

217.8 HIGH DENSITY POLYETHYLENE PIPES (HDPE)

217.8.1 Quality Requirements

HDPE pipes and fittings shall comply in all respects with the following standards.

BS 6572 - 1984 -	Specification for blue polythylene pipes up to nominal size 63 for below ground use for potable water.
WIS 4-32-02	Specification for polyethylene pressure pipe for cold potable water (underground use).
WIS 4-32-04	Specification for polyethylene socket and spigot fittings, saddless and drawn bends for fusion jointing for use with cold potable water PE pressure pipes.
WIS 4-32-06P - 1989 -	Specification for polyethylene electrofusion couplers and fittings for cold potable water supply for nominal sizes up to and including 180.
WIS 4-32-13P - 1991 -	Interim specification for higher performance blue polyethylene(PE/MRS 100) pressure pipes (nominal sizes 90 to 500) for underground or protected use for the conveyance of water intended for human consumption.

(WIS Water Industry Specifications UK).

DIN 8074/ DIN 8075 or the most recent ISO standards or European Norms (EN12201 part 1 and part 2).

All pipes and fittings shall be manufactured from approved raw materials and shall be supplied by approved manufacturers. Manufacturers shall have and maintain permanent Quality Control program and records.

Unless otherwise stated, pipes with OD up to 63mm must be produced from PE80 (MDPE) or PE100 (HDPE) material. Pipes with OD 75 mm and up must be produced from PE100 (HDPE) material. Pressure class for all diameters should be PN16.

Pipes with OD up to 63mm shall be supplied in coils where the inside diameter of the coil is 30 times OD. Pipes with OD 75mm and up shall be supplied in coils if possible or in straight length not less than 6 m.

The pipes shall be clearly and indelibly marked to show the name of the manufacturer, nominal diameter, wall thickness, PE designation, pressure class, standard (BS, DIN, EN, ...) and date of manufacture. The marking shall remain legible during normal handling, storage, installation, and service life and shall be applied in a manner that will not reduce the strength nor otherwise damage the products. The marking shall not initiate any defects in the surface and will not provide leakage channels when elastomeric gasket compression fittings are used to make joints. Both hot tape marking and Ink Jet printing are acceptable.

For instant identification as potable water service pipes, PE pipes shall be colored blue or black permanently color-coded with blue stripes. Stripes shall be provided by co-extruding four (or more) equally spaced blue color stripes into the pipe outside surface. The striping material shall be the same material as the pipe material except for color. Stripes printed on the pipe outside surface shall not be acceptable.
For applications other than potable water, i.e. Irrigation and drainage, pipes are to be colored black.

Pipes and fittings intended to be used for the conveyance of potable water shall be approved by an internationally recognized independent water authority such as WRC, DVGW, KIWA, Lyonnaise Des Eaux, etc... The effect on water quality test shall fulfill the requirements of BS 6920 or equivalent.

HDPE pipes shall be factory tested and shall be subjected to Hydraulic, Impact (Falling Weight) and acceptance Tests. The number and selection of samples for testing, the test procedure and the requirements shall all be as specified in the relevant EN. If so directed by the Engineer, the selection of samples and the Tests shall be witnessed by a representative of the Engineer, who shall be informed at least 48 hours in advance of any sampling or testing.

The cost of samples, their transportation to the laboratory and their testing shall be deemed to be included in the unit rates and shall not be paid for separately.

217.8.2 Hauling, Handling and Storage

Rough handling of pipes shall at all times be avoided, especially at low temperature, and care should be taken to prevent damage to pipes and fittings at all stages of handling, transporting and storage.

Pipes must be transported by a suitable vehicule and properly loaded and unloaded. Straight pipes should be supported along their full length.

When lifting with slings, only wide fabric choker slings shall be used to lift, move, or lower pipe and fittings. Wire rope or chains shall not be used. Slings shall be of sufficient capacity for the load, and shall be inspected before use. Worn or defective equipment shall not be used.

During storage, care must be taken to ensure that pipes do not become distorted or damaged. This can occur if pipe stacks are not properly constructed and are not limited in height. Pipe stacks must not exceed 1.5m and storage areas must be flat throughout the entire length of the pipe.

Pipes must be protected from materials which may soften or damage polyethylene, such as strong solvents.

Pipes must not be dragged across ground, which might damage the surface.

Similar precautions should be taken with fittings and these should be kept in protective wrappings until required for use. This is particularly important for all electrofusion fittings, each one of which should be individually wrapped and sealed immediately after manufacture.

It is similarly important to protect spigot ends of pipes and fittings to be jointed by Electrofusion or Mechanical jointing methods.

217.8.3 Weathering

Blue and yellow polyethylene should not be permanently installed above ground where it is exposed to direct UV light.

217.8.4 Laying

After the excavation and preparation of a section of pipe trench has been completed, it shall be inspected by the Engineer. Just before pipelaying the trench shall be cleaned of all stones, soil and other debris that might have fallen therein.

All pipelaying shall be carried out by experienced pipe-layers, well skilled in this work and in the presence of the Engineer unless prior permission has been received.

Immediately before being laid, each pipe and fittings shall be carefully examined both inside and outside for any damage, and all dust, dirt and foreign matter shall be removed. Care shall be taken to ensure that they remain clean during laying. The use of a badger will be ordered by the Engineer, if in his opinion, dirt is not being satisfactorily excluded. The badger, on a sound rope, is to remain within the bore of the pipe previously laid and joined and it is to be drawn forward as the work proceeds throughout the whole length of the pipe. The badger is to be of soft material which will not damage the internal surface of the pipes.

In order to prevent stones and soil from entering the pipe, a suitable cap or plug shall be provided with which the last pipe laid shall be closed when pipelaying is not actually in progress. The plug will be of the screw-up expanding type or of tapered wood.

Where bends are required, performed bends of the desired radiis shall be used. Hot bending on site is not permitted.

Additional general installation details for HDPE duct for telemetry cables

The line and level of the duct formation shall be kept as straight as possible. Bends will be required for duct formations to be routed around corners at intersecting roads. (For safety reasons manholes shall usually be planned and located away from intersections).

The configuration of the duct formation shall be as shown on drawings.

All ducts shall be located in accordance with applicable roads and municipal Standards. In the absence of relevant Standards, the Engineer must be consulted to ensure compliance with the appropriate standard which may vary depending upon the nature of the undertaking.

Ducts shall be watertight between manholes. Installation methods shall prevent sand and soil from entering the ducts.

At manhole, the bond between the outside surface of the duct and the wall shall be watertight.

Ducts shall be terminated flush to manhole inside walls. Edges shall be bevelled off.

Ducts entering manholes, shall be plugged and watertight. The plugging mechanism or material shall be readily removable to allow for future cable installation.

Ducts shall leave a manhole in a standard formation and enter the subsequent manhole with each duct in the same relative location.

At location between manholes where the duct formation must be modified due to obstructions the formation shall be altered to minimise the movement of each duct.

The separation either longitudinal or perpendicular, to other services, should be minimum 150mm. Where such is not possible a separating/retaining layer of 50 mm of concrete is required.

The Engineer shall have the authority to change the construction method to HDPE in concrete or steel ducts, should the circumstances indicate such a requirement.

If two ducts are to be laid, they shall be supported by spacers so that the formation will maintain the standard spacing between ducts throughout the length of the installation. Sand, to the appropriate highway specification, shall be placed to fill all spaces between ducts, and compacted.

The duct formation shall be covered with 200 mm of sand. This is to be followed by approximately 200 mm of suitable backfill and a plastic warning tape. Warning tape shall be 70mm wide, yellow PVC, durably marked with the text ‘WARNING - TELEMETRY CABLE’ at no more than 50 cm intervals. Backfill and compaction shall follow.

HDPE tubes shall have minimum 2” inside diameter and minimum 5mm thickness with manholes maximum 100 meters apart.

217.8.5 Jointing

Jointing of HPDE can be one of the following systems:

a) Electro-fusion Fittings and Saddles

Electro-fusion can be used for all polyethylene pipes irrespective of size and pressure rating as long as pipe and fitting are manufactured from polyethylene resin of the same class and series. It is possible to use fittings with higher pressure rating than pipe, but the opposite is strictly forbidden.

- All fittings shall be injection moulded from recognised top quality PE 100 or PE 80 resin.
- All fittings must conform with the requirements of the related standard EN, BS, ..
- All fittings must be packed in such a way to allow instant use on site without additional cleaning.
- Each protective package must clearly indicate its contents.
- The heating coils contained in each individual fitting and saddle should be so designed that only one complete process cycle is necessary to fully electro-fuse the fitting to the adjoining pipe or pipes.
- No heating coil may be exposed and is to be fully imbedded into the body of the fitting for protection purposes during assembly.
- The pipe fixation device shall be an integral part of the fitting body in the sizes up to and including nominal diameter 63 mm.
- An individual magnetic card containing a magnetic strip and an appropriate barcode for data transfer purposes must be supplied with each fitting.
- All fittings must have moulded-in identification and product information.
- Process voltage of all fittings must not exceed a maximum of 40 volts.
- Insulated contacts for the terminal pins are to be provided.
- Terminal pin size shall be 4 mm in diameter.
- A limited path style fusion indicator acting for each fusion zone as visual recognition of completed fusion cycle should be incorporated in the body of the fitting.
- The design of the indicators must prevent the escape of fusion melt.
- All couplers in the sizes up to and including nominal diameter 160 mm must have an easily removable center stop not requiring tools for removal.
- All internal or externally threaded transition adaptors in the nominal sizes up to and including 2” must be designed with an integral polyethylene collar form PE 100 or PE 80 not relying on rubber or synthetic seals.
- Threaded adaptor bodies may be from brass or stainless steel and should be of the modular principle not being supplied moulded into an electro-fusion fitting socket.
- Electro-fusion machines used in the electro-fusion process must be supplied by the same manufacturer of fittings. It strictly forbidden to fuse one manufacturer fitting with another manufacturer machine.

Additional Requirements for Electro-fusion Saddles

- All saddles up to nominal diameter 250 mm should be designed with two separate halves having a single hinge type attachment and are to be correctly processed without specialized external spring-loaded tooling.
- The top half of the saddle shall be equipped with an outlet which can accept various other system components such as tapping tees, adopters, valve tees, stop-off attachments etc., that are simultaneously fused together with the saddle to mains joint in one operation.
- Each branch outlet is to be equipped with an integral clamping device.
- The branch spigot of tapping tees must be long enough to allow a second joint if necessary.

- All pipe saddles sizes above nominal diameter 63 x 20 mm are to allow a 360^{o} rotation of the branch outlet.
- Safe tapping into a main must be possible under the defined allowable maximum water pressure according the respective pipe series and ambient temperature.
- The tapping saddle cutter is to be designed to seal-off the central passage in the uppermost position.

b) Butt-fusion:

Butt-fusion jointing is a thermofusion welding process which invloves the simultaneous heating of the annular end sufaces of two components to be joined until a melt state is attained on each contact surface. The two surfaces are then brought together under controlled pressure for a specified cooling time and a homogeneous weld is formed upon cooling.

The resultant joint is end thrust resistant and has comparable performance under pressure to the unwelded pipe.

In the fabrication and installation of a butt-welded polyethylene system, it is essential that all items which are to be butt-welded are made from compatible material.

The compatibility is dependent upon the process of manufacture, density amd melt flow index.

It is also important that proper butt-welding machines are used to make welds and that these are maintained in good condition as welding pressures and temperatures are critical to achieving satisfactory welds.

c) Compression Fittings

All fittings must be manufactured of pure virgin compounded PP ensuring the best performance as to mechanical properties and flexibilities.

- All fittings must be Push-fit type: to assemble, the installer must just cut the pipe square and clean (no need to chamfering), loosen the nut, push the pipe all the way through the stroke and close the nut. The fittings should be easily disassembled without the need for a special tool.
- All fittings must have a floating split clamp ring to compensate thermal and mechanical stress on the pipe. (Ring must be made of acetalic resin or C-PVC).
- All fittings must have a heavy-duty thrust ring to ensure axial compression of the gasket on ovalized, undersized and scratched pipes.
- All fittings must have a gasket. giving the gasket a broader contact surface with the pipe, allowing a tighter grip and a higher resistance in case of vacuum or suction. Also, permitting higher protection against pipe pullout (Gasket must me made from EPDM or NBR Rubber).
- All female offtakes must be reinforcing with metal rings (Rings must be made of stainless steel).
- All fittings must have an easy traceability of the production batch. The production date must appear on the fitting's body and/or nut.

Certificates and Approvals:

All fittings must pass the testing requirements of ISO 3458/3459/3501/3503. At the time of submission, Manufacturers of fittings must hold valid certificates of conformity in respect to the following:

Toxicological requirements:

- WRc * Low sensitivity to bacteria migration
- DVGW * Low sensitivity to chlorine absorption
- KIWA * Alimentary compatibility as ATA test for color, odor, taste and toxic components in concentrations - BRL-K533

Ageing Test requirement:

- DVGW * 95^{o} C - 1,000 hours - 0.5 x Nominal Pressure (PN)

Pullout Test requirement:

- WRc * For sizes up to 63 mm Diam.
- UNI9562 * for sizes greater than 63mm Diam.

Pressure test requirement:

- IIP * 3 x Nominal Pressure (PN) - 1 hour - 20^{o}C Water Temperature

Clamp Saddles

All clamp saddles must be manufactured of pure virgin compounded PP ensuring the best performance as to mechanical properties and flexibility.

– Clamp saddles could be used on distribution lines of 63mm and below, for section rated at PN16 bars or less.
– All saddle off-takes must be reinforced with metal stiffeners.
– All saddles must have a feature to prevent bolt's rotation during assembly.
– All saddles over 40 mm and outlets ½" to 2" must have flat gasket to ensure added flexibility on ovalized, undersized or scratched pipes and to prevent gasket's pulling-out in case of water hammer.
– All bolts and nuts should be from stainless steel (series 400).

217.8.6 Testing

Testing instructions and requirements for HPDE gravity pipelines shall be as specified in Subsection 217.2.6 except that the leakage under test shall not exceed 0.08 litre/m2 of internal wall pipe area/hour. Testing instructions and requirements for HPDE pressure pipelines shall be as specified in Subsection 217.3.10 (b) for A.C. pressure pipes, except that the Hydrostatic pressure test can commence 24 hours after the completion of filling if permitted by the Engineer. Manufacturer's recommended procedure of testing should be submitted to the Engineer who could accept to take it into consideration or not.

217.8.7 Methods of Measurement and Payment

HPDE pipes shall be classified for payment according to type, diameter and class and shall be measured in linear meters of completed pipeline in place, along the crown of the pipeline, as follows:

- In gravity flow lines: between internal surfaces of manholes or chambers.
- In pressure flow lines: between stations.

The length measured for payment shall include the length of all fittings, valves and specials installed in the line.

Payment for HPDE pipes and for fittings; specials etc. include:

- Supply, hauling, handling, unloading and staking of pipes and fittings including all necessary HPDE joints and jointing materials for pipes and all HPDE joints and jointing materials for fittings, specials, valves, etc.

- Removal from stacks; hauling and stringing alongside trench; laying and jointing of pipes and fittings, at any depth of trench; connections to manholes and/or chambers and final cleaning and flushing of pipeline. The unit rates for this item, for each type, class and diameter of pipe and fitting, shall be the same for all depths of trench in which the pipes and fittings are to be installed.

- Testing of completed pipeline
  - For gravity pipelines: the cost of testing shall be included in the unit rates for pipes and shall not be paid for separately.
  - For pressure pipelines: the cost of testing shall be paid for under a separate item in the Bill of Quantities, by linear meters of pipe tested.

Only pipes, fittings, junctions, bends etc. actually laid in trench and tested and accepted by the Engineer can be measured for payment under the above items, and no allowance whatsoever will be made for any breakage, loss, waste, etc.

Excavation and backfill, special beddings, surrounds and manholes and chambers shall be paid for under separate items in the Bill of Quantities, unless otherwise stated.

217.9 WATER SERVICE CONNECTIONS

217.9.1 Scope

Service connections shall consist of pipes and fittings of small diameters which distribute water from the mains to the consumers.

The nature of these connections shall vary according to the main pipes material.

For DI mains, service connections shall include the following:
- Tapping collars
- Ferrules (Self-sealing fittings for vertical under pressure tappings)
- Stop valves
- Pipes and fittings

and shall end up with:
- House connection accessories

For HDPE mains, the tapping collars and ferrules shall be replaced with saddles and tapping tees respectively. The remaining components (stop valves, pipes and fittings and house connection accessories) shall be identical to those used for DI mains.

217.9.2 Ductile Iron Mains

217.9.2.1 Tapping Collars

Tapping collars shall be used for connecting DI mains to service lines. They shall be made from coated ductile iron with anti-corrosive bolts and shall have large threaded boss on which ferrules shall be vertically mounted.

Elastomer gaskets of appropriate shapes shall ensure the seal between the mains and tapping collar.

217.9.2.2 Ferrules (Self-sealing fittings for vertical under pressure tappings)

They shall be mounted on large threaded boss tapping collars for connecting mains to service lines.

They shall consist of:

- a body, ductile iron, threaded at its lower part, and screwed on under pressure tapping collars. A polyurethane gasket shall allow to obtain the required orientation of the fitting once the fitting is completely screwed to the collar.
- an ABS float valve (Acrylonitrèle - Butadiene - Styrene)
- a ductile iron seat coated with elastomer and screwed inside the body.
- a ductile iron cap fitted with a polyurethane gasket
- an internal threaded outlet on which a nipple for polyethylene or PVC pipe shall be mounted. No need for nipple if stop valves are directly connected to ferrules.

217.9.3 HDPE mains

217.9.3.1 Saddles

HDPE mains shall be connected to the service lines through electrofusion saddles, which are made from HDPE and consist of:

- An upper semi-cylindrical piece having a small cylindrical neck incorporated at the center of its convex face; a tapping tee shall be vertically mounted on this upper part through the above-mentioned neck.
  The seal between the upper part of the saddle and the main pipe shall be effected through electrofusion. To this effect, this upper part shall include two ports used to connect the electrofusion machine to the saddle. Two limited path fusion indicators shall also be present to indicate the point beyond which no more sealing is necessary. One of these ports shall be located on the semicylindrical surface of the upper saddle part and the other on the saddle neck to seal the saddle to the main and the tapping tee to the neck, respectively.
- A lower semi-cylindrical part that shall be attached to the upper one via two pin connectors from one side, the other side being joined together by the means of a hook, formed through appropriate fashioning of the upper and lower saddle ends. This lower part is used to fix the upper one in place prior to sealing this latter to the main through electrofusion.

217.9.3.2 Tapping Tees

They shall be mounted on the above-mentioned saddles for connecting HDPE mains to service lines.

They shall be made from HDPE and shall consist of:

- A lower cylindrical branch to be inserted in the saddle neck specified above.
- An upper threaded branch that could be closed with a screw cap of the same material (HDPE).
- An outlet branch that could be joined to the service pipe via a coupler, or could be directly connected to the stop valve.
- An O-ring sealed screw cap made from HDPE.

The seal between the tapping tee and the saddle shall be effected through electrofusion as above. The saddle neck shall also be equipped with two pin connectors to be tightened after inserting the tapping tee and orienting it in the right direction, and prior to sealing it to the neck.

As for the coupler connecting the outlet tee branch to the service pipe, it shall be sealed to these through electrofusion as well but shall include four pin connectors for better control before sealing, as well as two limited path fusion indicators.

217.9.4 Stop Valves

Stop valves shall be equipped with two push-in fittings for connecting standard polyethylene or PVC pipes (this could be applied either for DI or HDPE mains) or they shall be equipped at one end with a threaded nose for direct connection to tapping collars or ferrules installed on

the DI mains, and on the other end with a push-in fitting for standard polyethylene or PVC pipe in accordance with NFT 54-003, NFT 54072, ISO 161-1, ISO 3607 or any equivalent.

Stop valves shall consist of :

- a ductile iron body coated with powder epoxy or copper alloy, drilled for automatic draining of service line (after closing of the ferrule).
- a rotary inverted plug, copper alloy, ¼ turn, fitted at its upper part with an operating cap.
- a ductile iron base coated with powder epoxy and screwed to the body lower part. The base and the body shall be of the same material.
- a stainless steel spring supported by the screwed base and pushes the inverted plug against the body.

Stop valves shall be protected by complete systems of surface boxes for operation from the surface. These boxes shall consist of a lower protective hood which shall contain the valve and isolate it from the surrounding soil. The hood shall be surmounted by a PVC extension tube which shall house the spindle used to operate the stop valve (Each stop valve shall be equipped with such a spindle). Finally, the extension tube shall be topped by a surface box made of ductile iron, the cover of which shall be flush with the sidewalk surface and the entire assembly (stop valve, spindle, hood, tube, surface box) located outside the property line.

The stop valve shall be at least 60cm beneath the road surface.

217.9.5 Service Pipes

Service pipes shall be from HDPE. For further information, refer to section 217.8.

217.9.6 Test Pressure

Service connection fittings shall undergo a double hydrostatic test:

1. a mechanical strength test, in opened position, under the maximum allowable pressure increased by 50%:
2. a seal test, in closed position, under the maximum allowable pressure increased by 10%:

Test certificate from factory or from approved laboratory shall be submitted with the equipment.

217.9.7 House Connection Accessories

House connection accessories for each consumer shall consist of a ball valve followed by a water meter and then a pollution check valve including all necessary fittings.

House connection accessories shall be protected by adequate water meter boxes. These boxes shall have generally three sizes: first size for individual consumers, second size for three subscribers and a third size for five subscribers. In these two latter cases, a collector linked to the downstream end of the service line shall distribute water to each house connection.

For pricing purposes, this collector shall be considered an integral part of the water meter box(es) it is supplying.

Water meter boxes shall be watertight, and equipped each with a lock to prevent unauthorized access. These locks shall be identical for a given number of boxes. This number may vary according to the Engineer's request. In addition, a sight glass shall be installed on each meter box cover to provide a proper reading of the water meter measurements without having to open the meter box.

For each group of similar locks, shall be provided a corresponding set of 5 identical keys.

The boxes shall be located inside the concerned property, and shall be provided by the Contractor. Their exact location shall be approved by the Engineer.

217.9.8 In Situ Testing and Method of Payment

Service lines shall be from HDPE, equipped where required with a ferrule mounted on the tapping collar installed on the main (for DI mains) or with a tapping tee on a tapping saddle in the case of HDPE mains, a stop valve installed on the service line and a ball valve installed at the end of the service line directly upstream the water meter.

Hydrostatic tests are conducted in two stages on service connections and DI mains at the same time:

1. The main is put under test pressure with ferrules and/or stop valves closed - The network tightness is monitored.
2. Ferrules and stop valves are opened and ball valves closed, the seal of service connections, under the same test pressure as stage 1, is monitored.

The same procedure shall be followed for HDPE mains (use tapping tees in place of ferrules).

Service connection testings shall be paid separately by unit of service connection.

217.10 MICROTUNNELLING SYSTEM

217.10.1 Reinforced Concrete Jacking pipes

217.10.1.1 Static Strength Calculation

The static strength calculation must be done for all expected load cases in axial direction of the pipes (jacking force for straight or curve drives) and perpendicular to the pipe axis (pipe weight, ground load, internal and external water pressure, traffic load etc.) based on actual valid rules such as general rules for concrete works (DIN 1045), special rules for pipe design and pipe manufacturing (DIN 4035) and detailed rules for the static strength calculation for the specific system of pipe installation (open trench installation or pipe jacking).

Structural calculations for jacking pipes must be according to worksheet ATV-A161- (Driven pipes, Edition I/90).

217.10.1.2 Concrete and Reinforcing Steel

Reinforced concrete pipes, to be manufactured according to DIN 1045 and DIN 4035, using approved steel, aggregates, cement (sulfate resistant if need), admixtures and water.

1. Reinforcing steel must be of weldable quality (BSt 500 P / BSt 500 S or similar), fulfilling all tests after cage welding procedure according to DIN 488.

2. The reinforcing cages have to be produced by automatic welding machine according to the structural strength calculation and pipe design.

3. For pipes of a wall thickness of 120 mm or more, two layers of concentric cages must be foreseen, which should be completely embedded in the concrete.

4. A minimum of 30 mm concrete cover must be secured, using special polymer-concrete spacers with roughened surface securing homogeneous adherence to the concrete.

5. Cage design, rod and coil sizes, spiral spacing and relevant dimensions must be as per ATV-A161.

217.10.2 Pipe Design and Geometry

1. Jacking pipes should be spigot/socket type, where the spigot includes an incorporate precast groove, allowing for the installation of a rubber seal joint, whereas the socket must be a steel collar including a prewelded steel water stop.

2. The steel grade of the collar should be corrosion resistant to the soil and water at the installation level. Such resistance to be calculated as per DIN 50929 / P3 considering the soil and water analysis. If the pipes are installed near the sea on coastal areas the collar should be stainless steel.

3. Standard mild construction steel according EN 10025 or steel containing chrome and molybdium, to be selected depending on the corrosion resistance calculations.

4. The thickness of the collar must not be less than 8 mm for mild steel and not less than 6 mm for stainless steel, respecting the corrosion resistance standard, but in any case should be designed to resist the physical forces resulting from the allowed angular deviations.

217.10.3 Handling Anchors

Each pipe must include 4 anchors, whose load resistance must be approved, two of which to allow for pipe handling at site and for transport, whereas the other two to be used for lifting and titling the pipes upon production. (DEHA anchors or similar).

217.10.4 Pipe Particulars

1. At least each third pipe of the jacked sequence should be a special pipe including three outlet nozzles to allow for external surface lubrication during pipe jacking. These nozzles to be precast during production.

2. Special pipes of long-sockets to be foreseen, as per design, to allow for the use of intermediary jacking stations.

3. As a compression absorber, each pipe, must include at the socket side a wooden ring of a thickness of 20 mm.

217.10.5 Joint seals

1. For the pipe joint sealing a slip-ring seal made of elastomer rubber of dense structure for permanent sealing has to be used. The seal compression should be of a minimum of 25%.

2. The pipe joint design, (spigot groove, rubber seal and steel collar) shall be designed to resist the internal and external hydrostatic pressures at the installation zone, but in any case should resist an internal pressure of at least 1 bar and an external pressure of at least 2.0 bars.

3. Joint of pipes used for storm water, do not need any internal treatment.

4. Joints of pipes for clear water transport, (eventual potable use), must be sealed with approved polyurethane base mastic, as recommended by the manufacturer.

217.10.6 Internal Pipe Lining for Sewage Pipes

1. The reinforced concrete pipes used for sewage shall be produced with 360° - Lining to prevent from corrosion due to the sewage and gas inside the tunnel.

2. The lining must cover the full pipe length, where the joint zone must also be sealed using thermoplastic hot air extrusion welding, applied by an automatic (satellite) device.

3. Minor repairs and patching the outlet nozzles, could be carried out by manual hot air thermowelding, using the welding rods as recommended by the manufacturer of the liner.

4. A joint strip of the same lining material has to be welded to both sides of the joint (recess joint system). This strip must be of a thickness of at least 3mm.

5. The lining to be of HDPE with minimum thickness of 2.0 mm.

6. The lining must be of the stud type securing resistant adherence (embedment) into the concrete resisting an external pressure of at least 2.0 bar.

217.10.7 System Pipe Length

Jacking pipes to be of a length of 3 meters. Shorter pipes could be used to allow for curved drives, as per ATV 161, as well as for length compensations at the connections to manholes and others.

217.10.8 Pipe Manufacturing

The pipes shall be manufactured according to the above mentioned standards in best quality, using special pipe molds with hydraulic shrinkable internal cores and expandable external molds.

The pipes should be kept for at least 4 hours inside the pipe molds to get high quality concrete and smooth pipe surface. During the first 10 hours after pouring the concrete curing shall be carried out by covering the pipes completely to conserve the humidity and avoid fast drying.

After production, the pipes should be sprayed with water for 2 days securing high surface concrete strength.

217.10.9 Microtunneling System and Machines

1. The tunneling machine and relevant logistics must be an integral system supplied by the same manufacturer, where the steering and guiding system are to be operated from the computerized, above ground, control room.

   The cutting wheel, its tools, and relevant selection of rock cutting and / or clay handling - etc must be adequately selected considering the soil condition, water table and ground cover.

2. The control plc / ddc system must control all the equipment, as well as their components, where a selectable manual / auto mode is allowed.

3. The computer, and display monitor, must sense and process the mechanical and hydraulic components, as well as the laser beamer, but not limited to:

   3.1. Cutting wheel, torque and rpm, both variable and controllable.

   3.2. Steering cylinders: course control and pressure indication.

   3.3. Roll and yawe display, and limiting levels control.

   3.4. Pitch and level sensing and control.

   3.5. Driven length indication.

   3.6. Main jacking cylinders pressure and speed control.

   3.7. Intermediary jacking station, pressure and course control.

   3.8. Lubrication and slurry pressure control.

   3.9. Laser magnitude and intensity control.

   3.10. Oil level and temperature control.

   3.11. Slurry flow and pressure at both supply and return lines (valid for slurry system).

218 - ROAD WORKS

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218 ROAD WORKS

218.1 ROADS AND PAVED AREAS

218.1.1 General

Road construction under this division shall include construction of new roads and paved areas and repairs to existing roads and paved areas where such repairs are necessitated by the performance of the Works, and the term "road" as used in this division shall also include other areas on which a road surfacing is required.

All roads shall be constructed to the lines, levels and cross-sections shown on the Drawings and as detailed in the Particular specification. Road surfacing may consist of compacted local soil, gravel, laterite or similar suitable material, with or without a stabilizing spray of bitumen, or of asphalt concrete placed on a bearing course of compacted gravel, laterite or other suitable base course material.

All roads shall be fitted with a stormwater drainage system, sidewalks, etc.

218.1.2 Earthworks for Road Construction (Subgrade)

All excavation and fill required for road construction shall be carried out in accordance with the applicable requirements of Division 201. The materials to be used and the degree of compaction to be obtained in each layer of the road structure shall be as shown on the Drawings or as required in the Particular Specification.

218.1.3 Sub-Base and Base Courses

Sub-base preparation shall consist of the following:

- Scraping of the natural ground
- Earthworks and levelling of the surface
- Compaction with a pneumatic roller.

Unless otherwise specified, sub-base material shall consist of hard, durable particles or fragments of stone or gravel, screened and crushed to the required size and grading or an equivalent material, subject to the Engineer's approval. The material shall be free from vegetable matter, lumps or balls of clay and other objectionable matter.

The sub-base shall be levelled, watered, rolled and compacted to 96% of the Modified AASHTO Density. In case it consists of non-rock ground, the California Bearing Ratio CBR shall be greater than 30. The Material shall have a specific weight greater than 2.45 kg/dm^3.

If the bearing of the foundation soil be inadequate, the top soil shall be stripped to a 20cm depth. The stripped area shall be backfilled with material that meets the requirements and have a minimum CBR of 15 when compacted to 96% of Modified AASHTO Density. The frequency of tests shall be determined by the Engineer.

The sub-base course material layer shall conform to the following grading:

A.S.T.M.Sieve Designation	Percentage by Weight Passing Square Mesh Sieves
1"½	100%
1"	60-100
¾"	55-85
No. 4	35-60
No. 10	25-50
No. 40	15-30
No. 200	0-15

The material shall have the following properties:

- Plasticity Index (AASHTO T90) 4-8
- Plastic Limit (AASHTO T89) 25 maximum
- Sand Equivalent (AASHTO T176) 50 minimum

Unless otherwise specified, base course material shall be crushed aggregate which shall consist of hard, durable particles or fragments of stone or gravel crushed to the required size, and a filler of sand or other finely divided mineral mater. When produced from gravel, not less than 50 percent by weight of the coarse aggregate shall be particles having at least one fractured face and, if necessary to meet his requirement or to eliminate an excess of filler, the gravel shall be screened before crushing. All suitable oversize material less than 10 inches in diameter shall be crushed. The material shall be free from vegetable matter, lumps or balls of clay and other objectionable matter.

The sub-base and base courses shall consist of a minimum of 20 cm thick each course of compacted layers of screened and crushed material.

The sub-base shall be watered prior to the placing of the base course. The material shall then be laid, watered and compacted with a pneumatic roller to 98% of Modified AASHTO Density.

The last base course shall be levelled to ± 1 cm according to the levels shown on the drawings or specified by the Employer. Newly placed base courses shall not be opened to traffic.

The base course material shall have a specific weight greater than 2.45 kg/dm^3 and shall conform to one of the following gradings:

A.S.T.M.Sieve	Percentage by Weight Passing Square Mesh Sieves								
designation	A	B	B-1	C	C-1	D	D-1	E	E-1
3 inch	100	-	-	-	-	-	-	-	-
2 inch	-	100	100	-	-	-	-	-	-
1 1/2 inch	-	-	70-100	100	100	-	-	-	-
1 inch	-	-	55-85	-	70-100	100	100	-	-
3/4 inch	-	-	50-80	-	60-90	-	70-100	100	100
3/8 inch	-	-	40-70	-	45-75	-	50-80	-	-
No. 4	15-45	20-50	30-60	25-55	30-60	30-60	35-65	35-65	45-80
No. 10	-	-	20-50	-	20-50	0	25-50	-	30-60
No. 40	-	-	10-30	-	10-30	0	15-30	-	20-35
No. 200	0-10	0-10	5-15(*)	0-10	5-15(*)	0 - 10	5-15(*)	0-10	5-15(*)

(*) For gradings B-1, C-1, D-1 and E-1, the fraction passing the No. 200 sieve shall not be greater than two-thirds of the fraction passing the No. 40 sieve.

If no specific grading is specified, the grading shall comply with C above.

If fine aggregate or filler in addition to that naturally present in the base-course material is necessary in order to meet the grading requirements or for satisfactory bonding of the material, it shall be uniformly blended with the base-course material at the screening and crushing plant or on the road. The material for such purpose shall be obtained from sources approved by the engineer and shall be free from hard lumps.

That portion of the base course material passing No. 40 sieve shall be nonplastic.

The base course material shall be tested for abrasion in accordance with B.S. 812 and the following maximum values shall be acceptable.

Aggregate fraction	Maximum abrasion (%)
3/4” - 1”	40
1/2” - 3/4”	35
3/8” - 1/2”	30
1/8” - 3/16”	28

Sub-base and base courses shall be placed in layers not exceeding 15 cm in thickness, after compaction. Unless otherwise specified, base course materials shall be placed only by means of spreader boxes or equivalent equipment. Placing base course materials directly by means of trucks, shovel dozers and other loading or hauling equipment will not be permitted. Blending material, where required, shall be added by means of spreader boxes or other approved equipment and the whole base course layer shall be thoroughly mixed to its full depth by means of graders, mixers or other approved equipment.

During placing and mixing, water shall be added in the amount necessary to provide the optimum moisture content for compacting.

Compaction shall be carried out in accordance with the applicable parts of Section 201.7.

Unless otherwise specified, the following densities shall be required:

- For sub-bases: 96% of the Modified A.A.S.H.T.O. Density
- For base-courses: 98% of the Modified A.A.S.H.T.O. Density

218.1.4 Bituminous Prime Coat and Tack Coat

Unless otherwise specified, a prime coat of medium curing cut-back bitumen of grade MC-70 shall be applied on top of finished base course, at the rate of 1.0 kg/m^2, and a tack coat of rapid curing cut-back bitumen of grade RC-250 shall be applied between asphalt concrete layers (where more than one wearing course is specified), at the rate of 0.25 kg/m^2.

Bituminous coats shall be applied one day before the next layer is placed on top of them. Prior to applying bituminous coats, the road surface shall be thoroughly cleaned of all dirt, oil, grease and other objectionable matter, to the satisfaction of the Engineer. The bitumen shall be heated in boilers of an approved type and spreading shall be carried out by means of mechanical pressure distributors.

218.1.5 Asphalt Concrete Wearing Courses

The number of asphalt concrete layers to be placed in the road surfacing and the thickness of each of them shall be as shown on the Drawings and/or required in the Particular Specification.

All aggregates and bituminous materials to be used in asphalt concrete shall be subject to approval by the Engineer. Samples of the materials shall be submitted to the Engineer at least 30 days prior to their use.

All aggregates, except natural sand, shall be obtained by crushing natural quarry stone, and the use of river gravel, whether crushed or not, will not be permitted. Coarse aggregate shall be of uniform quality, with the particles as nearly cubiform as possible, clean of dust or foreign matter, and shall comply with the requirements of Subsection 218.1.3 above for base course aggregate. Quarry sand shall be clean and free of clay, silt or other deleterious matter; it shall all pass sieve No. 10 and not more than 10 percent of it shall pass sieve 200. The grading of the aggregates shall be if not specified in the Particular Specification as follows:

A.S.T.M.Sieve Designation	Percentage by Weight Passing Square Mesh Sieves
¾“	100%
½”	80-100
No. 4	50-70
No. 10	32-47
No. 40	16-26
No. 80	10-18
No. 200	4-10

Mix design shall be carried out as follows. The proposed aggregate mixture shall be mixed with 5.5% bitumen (if no other percentage is required in the Particular Specification). This sample shall be subjected to a set of Marshall tests (A.S.T.M.-D-1559 and A.S.T.M.-D-1188) at a laboratory in order to determine the optimum bitumen content. The Engineer may change the grading of the aggregates and the bitumen content according to the results of laboratory tests conducted on samples of materials supplied from time to time by the Contractor at the request of the Engineer.

Placing of asphalt concrete, unless otherwise specified, shall be carried out by means of paving finishers, specially designed for that purpose. The asphalt concrete layers shall be compacted by tandem rollers, heavy pneumatic rollers and three-wheeled rollers, in that order to reach a density not less than 97% of the Marshall density. Parts of the layers inaccessible to heavy mechanical rollers shall be compacted by small vibratory tampers. Rolling shall proceed from the outer edges towards the centre of the road and the whole area shall receive a uniform compaction throughout and shall be finished accurately to the required lines and levels. When asphalt concrete is placed in more than one layer, longitudinal joints shall be staggered by 30 cm and transversal joints by 60 cm between layers. The permissible variations of the top surface from the design levels shall be -0 + 15 mm. The permissible variations from the plane in the top surface shall be 5 mm over a length of 5 m.

Newly paved asphalt concrete surfaces shall be opened to traffic only after permission to do so is given in writing by the Engineer.

Placing of asphalted concrete shall ensure an inclination for drainage of stormwaters in accordance with the drawings and as specified by the Engineer.

218.1.6 Bituminous Surface Treatment

Where shown on the Drawings or required in the Particular Specification, a surface treatment shall be applied to the base course by spraying cut-back bitumen followed by a rolled blinding layer of stone chippings. Unless otherwise specified, bituminous surface treatment shall consist of the following two layers:

- Cut-back bitumen MC-3000 at the rate of 2.8 kg/m^2, followed immediately by stone chippings of 3/4" - 1" size at the rate of 27 kg/m^2.

- Cut-back bitumen MC-3000 at the rate of 1.35 kg/m^2, followed immediately by stone chippings of No. 4 - 1/2" size at the rate of 22 kg/m^2.

The second layer shall be placed after the first layer has been rolled.

Prior to application of bituminous spray the base course surface shall be checked for accuracy and any irregularities shall be repaired. The surface shall then be swept clean of all loose material, foreign matter, dust and dirt. Areas contaminated by kerosene or diesel oil shall be removed and made good with clean and stable base course material.

The bitumen shall be heated in kettles of an approved type equipped with enclosed thermometers, the heat being conducted by oil or steam. Heating of bitumen in the barrels will not be permitted.

The entire area of the base course shall be sprayed uniformly at the prescribed rate by means of approved mechanical spraying equipment. Pools of excess liquid bitumen shall be sprinkled with fine sand which shall be swept off after it has absorbed the surplus bitumen.

The stone chippings shall be uniformly applied upon the entire sprayed surface. Trucks or other equipment for spreading the chippings shall be operated backwards so that the bituminous spray will be covered before wheels or workmen pass over it. Supplementary spreading and smoothing, where necessary, shall be done manually.

Following spreading and smoothing of chippings, each layer shall be rolled, to the satisfaction of the Engineer.

The completed road surface shall not be opened to traffic until permitted by the Engineer.

218.2 DRAINAGE SYSTEM

Stomrwater discharge channels and drainage systems shall be installed as shown on the drawings.

Excavation limits of channels and pipes as shown on the drawings shall be extended by 10 cm at the bottom and 30 cm on either sides.

Such over excavations shall be backfilled with graded fills and compacted to the satisfaction of the Engineer.

Excavations shall have a longitudinal slope as specified by the Engineer to facilitate water discharge.

The concrete drainage channels shall be either of precast or of cast-in-place concrete complying with the requirements of division 202.

Where specified, construction and expansion joints shall be performed to the details shown on the drawings and as directed by the Engineer.

A collector fitted with a metallic grid shall be mounted on channels and pipes as shown on shop drawings.

218.3 SIDEWALKS

Where specified on Drawings and required by the Engineer, sidewalks shall be executed.

Prior to the construction of sidewalks, the base course shall be prepared as determined in the previous articles. The Contractor shall be held liable for any future settlement of such layer.

Pavement works shall start upon the approval of the Engineer, and as shown on shop drawings.

For concrete paving, the flags shall be of an approved colour and laid in compliance with the requirements of the division 208, and in strict accordance with the lines and levels shown on shop drawings.

218.4 CONCRETE KERB-STONES

Precast concrete kerbs, channels, etc. shall be to the types and dimensions shown on the Drawings and/or defined in the Particular Specification. They shall be whole, sound, without cracks, air bubbles or other defects, and shall comply with the requirements of B.S. 340. Where specified, kerbs, channels etc. shall be bedded and backed with C 15 P concrete. Joints between units shall be filled with a 1:2 cement mortar.

All kerbs, channels, etc. shall be aligned in strict accordance with the lines shown on the Drawings. Special terminal units shall be provided at the edges of the alignment. Where required, units shall be cast-in-situ to the lines and dimensions shown on Drawings.

Kerbs, channels, etc. in sharp curves shall be shorter than those used on straight lines, in order to ensure proper alignment.

218.5 TESTING

218.5.1 Testing on fill materials

All natural fine fills shall conform to the below listed requirements:

a) Complete Identification Tests

- Sieve analysis and sedimentometry
- Atterberg limits (liquid limit, plasticity index, shrinkage)

b) Test on organic soils

c) Standard Proctor tests with complete determination of compaction diagram

d) Modified Proctor tests with complete determination of compaction diagram

e) CBR tests at 95% of the maximum dry density.

The number of the aforesaid tests shall be as determined by the Engineer.

218.5.2 Tests on Backfill

Placing natural fine fill shall be controlled by the Engineer in the following manner:

Three series of the following tests shall be conducted on each backfilled layer or on every 250 m^3 of placed backfills:

Measurement of moisture content
Measurement of compactness (dry density)

218.5.3 CBR tests on natural ground

CBR tests shall be conducted according to relevant standards.

The frequency of tests shall be as determined by the Engineer.

218.5.4 Tests on crushed aggregates

The required tests on crushed aggregates to be used for roads are the following:

- Measurement of the specific gravity
- Measurement of the compressive strength on 7 cm side cube
- Los Angeles test
- Sieve analysis
- tests on organic soils according to French Standards
- Measurement of the sand equivalent.

A series of tests shall be carried out on each 500 m^3 of aggregates or as directed by the Engineer.

Following are the two density control tests to be carried out on site on each placed crushed aggregate layer:

- Either on each finished layer,
- Or on each 250 m^3 of placed aggregates,
- Or as directed by the Engineer.

218.5.5 Tests on concrete asphalt aggregates

Following are the required tests to be carried out on concrete asphalt aggregates:

- Los Angeles Test
- Specific gravity
- Sieve analysis
- Loss in weight
- Sand equivalent
- Any other test as specified by standard ASTM D 693-54.

Three series of tests shall be conducted on each 500 m^3 of furnished material or on any volume exceeding by 50% this number, as required in writing by the Engineer.

218.5.6 Tests on bitumen

- Penetration at 25° C
- Penetration at 163° C
- Ductility at 25° C
- Flash point

– Solubility in carbon sulphide at 20° C
– Paraffin content.

Whenever required in writing by the Engineer, the tests above shall be carried out on each furnished bitumen volume prior to manufacture of asphalt concrete, or on bitumen that is being used.

218.5.7 Tests on asphalt concrete mixture

The Contractor shall conduct:

1) Tests to determine the grading of aggregates and the bitumen content

2) Marshall tests to determine the stability and density of bitumen-covered aggregates.

These tests shall be carried out before the commencement of works and repeated to the satisfaction of the Engineer.

218.5.8 Quality Control Tests

– Control of grading

– Control of moisture content and temperature

– Control of bituminous mixture, 2 samples to be tested daily/mixing plant

– Control of mixing plant.

Grading control shall be conducted once a day on 10 kg of samples of aggregates before putting them in the mixing plant, and whenever required by the Engineer.

Control of moisture content and temperature shall be carried out twice a day; moisture content shall not exceed 0.5% and temperature variations ± 5° C.

The control of bituminous mixture shall be carried out on the bitumen content and grading. Each tested sample consisting of four distinct samplings shall be taken from the mixing plant at short intervals as to ascertain that the proportioning remains unchanged.

The tolerance on bitumen content is relatively ± 5% of the measurements daily average.

Permissible tolerances are:

– ± 5% of the percentage fixed for the average bitumen content
– ± 10% of the percentage fixed for the corrector filler content.

218.5.9 Control of placing asphalt concrete

Throughout placing and compacting aggregates works, the temperature shall be controlled permanently in order to be ≥ 135° C.

After compaction, density shall be equal to 98% of the Marshall density; one core sample shall be taken of each 1000 m^2 of finished layer. These samples shall also be used to control the layer thickness.

Where specifically called for, the level and regularity of the surfacing shall be controlled.

No layer shall be executed by the Contractor unless the underlaying one has been duly taken over by the Engineer.

218.6 ROADS - METHODS OF MEASUREMENT AND PAYMENT

Unless otherwise specified, roads constructed in accordance with the Drawings or on specific instructions of the Engineer, shall be measured for payment. Access and construction roads for the Contractor's own use and reinstatement of paved areas are referred to in Subsection 201.1.10 respectively, and shall not be paid for under this division.

Unless otherwise specified, roads, shoulders and sidewalks shall be measured for payment - each separately - by m^2 of completed road shoulder or sidewalk, classified by type of surface and/or by cross-section. The unit rates shall include for all necessary earthwork; supply, hauling, spreading and compaction of all sub-base and base materials, bituminous coatings, chippings and asphalt concrete; and for all materials, equipment and labour necessary for completing roads, shoulders or sidewalks, in accordance with the Drawings and the Specification, and to the satisfaction of the Engineer.

Concrete kerbstones, channels etc. shall be measured for payment in linear meters of kerbstone etc. in place, classified by type and size. The unit rates shall include for supply of units and all necessary materials for bedding and support, laying and jointing. The same unit rates shall be paid for both straight and curved alignment.

219 - LANDSCAPING

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219 LANDSCAPING

219.1 MATERIALS

219.1.1 General

Plant material shall be of best quality.

Plant material shall be approved by the Employer's Representative prior to delivery to jobsite.

219.1.2 Agronomic Soil for Planting Areas

(a) Nature

It shall be provided for a medium favorable for the growing of trees, shrubs and lawn (satisfactory content of available nutrients, no contamination by phytotoxic substances...). The Contractor shall provide and use soil amendments and organic or mineral fertilizers necessary for a good growing medium.

Grading shall be according to the contour lines. Import agronomic soil shall be added for lawn planting.

Such import soil shall not be extracted from a depth exceeding 0.6 m or from horticultural gardens. Soil shall be free from chemical herbicides, whether selective or not.

Moreover, the use of imported soil stored for more than one year, extracted from a depth exceeding 1.50 m and left untreated shall be prohibited.

Imported soil shall be non-calcareous, free from big clods, foreign or noxious matters, pebbles, plant debris, rhizomes ...

Imported soil for lawn planting shall be loamy and extracted from not more than 20 cm deep.

(b) Acceptance of extraction site

Prior to the supply of imported soil, the Engineer's Representative shall inspect and approve :

- the extraction site
- the maximum extraction depth which shall not exceed 0.60 m.

(c) Transport

After extracting the soil to the specified depth and with the appropriate means, it shall be transported in clean containers having no traces of petroleum by-products.

219.1.3 Fertilizers

Three samples of soil shall be submitted by the Contractor and at his expense to the approved agronomic soil, testing laboratory. The use of fertilizers shall be determined following the soil tests.

(a) Basic fertilizers

Basic fertilizers shall be added when placing the agronomic soil to maintain the chemical qualities of the soil, and keep plants in a healthy growing condition.

Soil pH shall be adjusted to be neutral (pH = 7) or slightly acid (pH > 6.5).

Oligo-elements shall also be added.

Type of fertilizers and method of application shall be as directed by the agronomic soil testing laboratory.

* packaging : in resistant plastic bags
* transport : in covered trucks
* storage : in a covered premise, stack of ten bags maximum
* delivery : fertilizers shall be stored on site for two (2) days minimum prior to their use.

(b) Surface fertilizers

Surface fertilizers are added when sowing and during maintenance.

(c) Pesticides

Pesticides shall be suitable for the required treatment and conform to the specifications of relevant laws.

The Contractor shall choose and be responsible for the required treatment type.

However, the Contractor shall inform the Engineer of the product nature and type, eight (8) days prior to any treatment.

219.1.4 Lawn planting

(a) Seed mixes

The Contractor shall propose the most suitable seed mix according to the climate for the approval of the Engineer.

(b) Lawn establishment

Weeds, roots, stones, etc ... shall be removed down to 0.20 m deep, and agronomic soil loosened over the same depth. The surface shall be brought to a smooth uniform grade and all clods broken up.

Seed shall be sowed by hand or by a suitable machine to the quantity determined by the Engineer and according to each type of seeds :

– light raking over ½ cm (0.005 m) deep in both directions for plowing in seeds
– light tamping with a 60 to 80 kg roller.

All sown areas shall have a regular vegetation.

219.1.5 Plant Support

Plants shall be supported according to the instructions of the Engineer's Representative. Stakes shall be cylindrical and straight-grained picea or hardwood. Pine stakes shall not be used. Stakes shall be 8 cm in diameter approximately and 4 meters high as a minimum.

219.1.6 Plants

(a) Origin

Trees and shrubs shall be provided from approved nurseries. The Engineer or his representative may request to inspect such nurseries. Trees shall be selected and tagged prior to extraction and delivery.

(b) Plants features

Homogeneous genetic origin and good quality are required. No variable physical shapes shall be accepted when planting trees in lines or homogeneous masses.

Plants shall be of good quality :

– free from disfigurements in the shape of the stem and roots.
– not dried up, even partially.
– not having its aerial part or roots suffering from necrosis due to frost or injuries or disfigurements caused by an animal or a weed (injuries do not include cuts due to pruning).
– have a sound terminal bud.
– have one leader (plants which leader is topped off in nurseries or during transportation shall be rejected)
– have abundant root hairs consistent with the plant size.

The trunk size of trees is only a matter of choice. When selecting the plants, special care shall be taken to the condition of the leader and to the plants spacing in nurseries.

N.B. :
The Contractor may propose other plant sizes provided that he complies with the Contract specifications.

(c) Size of root system

After extraction of plants delivered in containers or balled and burlapped, trees shall have sound and uniform roots which length is equal to or more than five times the tree trunk size.

The root system shall be ramified and uniform. The Contractor shall inform the Engineer or his representative of the date of extraction to allow for inspection and control.

(d) Delivery

Delivery includes :

- plants extraction; root extraction and pruning if necessary.
- packaging.
- loading and transport to jobsite at the date and under the conditions set by the Engineer.
- unloading.

Good recovery of plants relies mainly on good transportation conditions : plants shall not be exposed to sun during extraction and prior to planting.

Container-grown plants shall be planted immediately after extraction; as for balled and burlapped plants, they shall be planted one day after extraction as a maximum.

Upon delivery to site, bare roots shall be covered with good agronomic soil and rootballs with straw. Plants shall be accepted by the Engineer's Representative before planting. They shall be delivered with care to avoid injuries, breaking of the leader, buds... and sun exposure. Trees shall be delivered in containers or balled and burlapped according to the species and varieties and as directed by the Engineer's Representative.

Shrubs and ground covers shall be delivered in pots or polyethylene bags. Plants shall be transported in covered trucks. Transportation shall not be carried out in frosty weather or under excessive heat.

219.2 EXECUTION OF WORKS

219.2.1 Protection of Neighbouring Works

Prior to the commencement of works, the Contractor shall consult the drawings of existing networks and structures available in the competent authorities offices, for details concerning their nature and position.

The Contractor shall be solely liable for any accident due to ignoring or misreading such drawings.

Before building new structures, the Contractor shall consult the drawings of existing networks and determine their nature and position. The drawings submitted to him concern only the works to be undertaken in this Division, but other temporary or permanent structures could have been built and installed by other engineering fields.

The Contractor shall be the sole responsible for any damages that might occur during the works implementation and shall bear rehabilitation costs.

Necessary measures shall be taken to avoid any damage during the works to the various public or private structures (buildings, sewerage, house connections, pipelines, networks, cables, etc ...).

Should any disruption in the structures operation occur, the Contractor shall put back into service such structures at his own expense without any notification whatsoever from the Engineer.

The Contractor shall in no case pile any material on the public road and pavement. During works execution, he shall maintain the good condition of all public or private roads, networks, fences and installations whatsoever that may be damaged by his preparation, rehabilitation or cleaning works.

219.2.2 Grading

(a) Planting holes

Digging of planting holes shall be carried out under this Division. Holes are dug manually or mechanically provided that the minimum sizes are observed.

Planting holes shall be filled with agronomic soil having the characteristics described above.

Partial filling shall be with good agronomic soil to the level of the foot of the tree.

The bottom and sides of the hole shall be scarified over 0.15 cm deep (for the hole bottom) to encourage root penetration into a loose and aerated soil.

(b) Sizes of holes

Holes and trenches shall have the following minimum sizes :

* 1.50 × 1.50 × 1.00 m deep for trees and conifers planted in lawned surfaces.
* 0.30 m deep for surfaces planted with lawn and ground covers.
* 0.50 × 0.50 × 0.50 m deep (variable depth + 0.50 m) for shrubs and hedges.

The Contractor shall carry out the final clean up.

219.2.3 Agronomic Soil

When placing the agronomic soil, clods shall be broken up. After loosening, soil shall be placed over a 20 cm depth for lawn planting.

219.2.4 Fertilizers

Basic fertilizers shall be placed along with the conditioned backfill soil. Soluble surface fertilizers are maintenance products to be applied on lawn and leaves of trees and shrubs.

The use of fertilizers shall be determined by the soil tests. After placing fertilizers, treated surfaces shall be well watered. Fertilizers shall not be added in very hot weather.

(a) Placing basic fertilizers

* Organic fertilizers

For planted and lawned surfaces, sterilized organic compost shall be added during soil loosening over 0.30 m deep. The recommended dosage is 2 kg/m².

* Mineral fertilizers

Mineral fertilizers shall be added along with compost for the whole planted and lawned surfaces. The recommended dosage is 50 g/ m².

It is recommended to use slow release fertilizers :

– Trees	:	0.5 kg of organic fertilizer / planting hole 0.1 kg of mineral fertilizer / planting hole
– Shrubs and ground covers	:	0.2 kg of organic fertilizer / planting hole 0.05 kg of mineral fertilizer / planting hole

(b) Organic soil amendments

Peat moss shall be incorporated into lawned surfaces as a complement to fertilizers over 0.15 m deep. The recommended dosage is 10% on volume basis of lawned surfaces.

219.3 PLANTS

219.3.1 Species, Varieties, Sizes

Refer to the complete list of plants as shown on drawings.

219.3.2 Planting

Planting shall be carried out by competent personnel at the required periods and according to the standards of practice.

219.3.3 Pruning

Since trees are delivered balled and burlapped, no pruning is required. However, appearing roots shall be cut back to healthy tissue.

To compensate for pruned roots the top of the plant shall be lightly trimmed and all dead branches or those close together removed.

Although pruning and trimming ensure a healthy growth, plants balance shall be observed. Plants shall be cut to their final shape during maintenance works. Major cuts shall be covered with a grafting wax.

219.3.4 Planting Times and Methods

Balled trees and shrubs shall be handled carefully and set in the hole. The space around the plant shall be filled with loose and fine-textured soil and gently tamped as the hole is filled to eliminate air pockets. Borders shall be pressed down to make backfills as firm as possible.

A ridge of soil shall be built up to form a shallow basin around the plant so that irrigation water will be concentrated in the area where it is needed most.

The basin can be broken down during soil preparation for lawn planting.

The plant shall then be watered eventhough the surrounding soil may appear wet. Watering shall continue until there is a perfect contact between the roots and soil.

Planting shall be stopped in extreme hot weather or if the soil becomes too muddy during rainfalls.

219.3.5 Stakes and Guy Lines

* Stakes

Stakes shall be anchored in the bottom of the planting hole at 50 cm deep approximately.
Stakes shall be set prior to placing agronomic soil.
For planting a line of trees, each stake shall be aligned with the other in a perfect geometrical figure.
Stakes shall be loosely tied to the plant by using two soft collars.

* Anchoring (where stakes cannot be used)

Guy lines and compression springs shall be used upon approval of the Engineer or his representative.

219.4 LAWN PLANTING

219.4.1 Soil Preparation

Lawn shall be planted on a clean smooth surface, with a perfect grade and a 2% slope.

Too hard or dry soil shall be first plowed in one direction over 20 cm deep, then tilled with a rotary tiller and finely smoothed with a rake.

Loose soil, over 10 to 15 cm deep, shall be tilled with a rotary tiller and finely smoothed with a rake. Debris shall be cleaned up.

219.4.2 Sowing

Sowing shall be done crosswize by means of hand tools or power tools.

219.5 RECOVERY GUARANTEE

219.5.1 Definition and Period of Guarantee

* Plants

The Contractor shall be responsible for the healthy growth of plants during the year following the acceptance of works.
Missing plants or seriously injured or noticeably wilting plants shall be considered as dead plants and replaced under this guarantee at no additional cost to the Employer.

Replacing such plants shall not relieve the Contractor from maintenance works during the guarantee period.

Maintenance as specified hereunder shall cover the whole year of guarantee following the acceptance of the works.

* Lawn planting

Such guarantee shall be applicable regardless of the time period following sowing, if the lawn coverage is deemed unsufficient by reason of a modification of the environment or the supporting soil due to such works carried out by the Contractor as chemical weed control, etc ...

219.6 TECHNICAL MAINTENANCE CONSIDERATIONS DURING THE ONE-YEAR GUARANTEE

219.6.1 General

Unless otherwise specified by the Engineer, maintenance works must not lead to modifications in the technical features, nor in the aesthetics of landscapes.

The basic design as to level and plan shall be especially respected. Any modification proposed by the Contractor to improve the functional or aesthetic aspect of landscapes or facilitate maintenance shall be submitted to the Engineer for approval.

219.6.2 Clean-Up of Lawn and Pruning Clippings and Maintenance Products

Clean up operations include the removal of debris and products resulting from maintenance works as well as wastes, trash, lawn and pruning clippings. Such wastes and debris shall be removed daily and the Contractor shall remain the Engineer thereof.

Before removing wastes, special care shall be taken to prevent their strewing over the clean surface. No wastes whatsoever (grass, branches, flowers, papers, etc ...) shall be stored on access paths. They shall be removed with light tools. Dead leaves shall be raked and removed as specified for lawn and pruning clippings. Dead leaves or any other debris shall never be burned on site.

219.6.3 Line Trees or Isolated Trees and Conifers

Pruning

To allow for a quick and good healing of scars, clear cuts shall be done :

- of thinning out type
- without leaving a stump which prevents the formation of callus tissue
- as to avoid water stagnation.

Removal of dead limbs or stumps shall be done having regard to the callus tissue.

Tree wound dressing

Cuts over 2 cm in diameter shall be dressed clean by removing jagged edges. They shall be protected with a waterproof flexible and fungicidal product.

Such product shall be applied immediately after cutting or any eventual growth.

Trimming tools shall be disinfected before being used on another tree.

Training of young plants

Training of young plants shall include :

- selection of branches according to their conformity, orientation and strength to obtain a balanced shape.

- removal of dead, gnarled and useless branches.

- progressive pruning of low branches, maintaining however a balance between the top of the plant and the trunk or stem (1/3 to 1/2 of the trunk or stem for 2/3 to 1/2 of branches).

- removal of suckers and shoots.

Maintenance of architectural shapes

Architectural shapes shall be maintained by trimming small-sized annual or biennal shoots.

Symmetry, evenness, round shape and verticality shall be respected.

Staking and guying

Stakes and guy lines shall only be modified or replaced by a written order of the Engineer.

Stakes shall be kept in good condition throughout the maintenance period. The Contractor shall keep upright tilting trees due to the wind or the settlement of soil.

Very tight collars shall be adjusted to avoid strangling the tree. Broken stakes and collars shall be replaced with approved models.

Pest control

The Contractor shall be responsible for pest control of plants, and shall take any measure to maintain them in a perfect healthy condition.

Treatments shall be carried out in optimal weather conditions (no rainfall, wind, favourable temperature for product efficiency, etc ...). The choice of the active ingredient shall be conditional upon the parasite development stage and suitable for each particular case.

Products shall be applied by means of a suitable tool.

Treatment shall be carried out for all trees and shrubs. Where the trunk of a tree also requires treatment, it shall be specified in writing by the Engineer.

In the event of several successive applications active ingredients of different chemical families shall be used to prevent any tolerance phenomena.
The Contractor shall inform the Engineer or his representative of the date and hour of such treatments, specifying the active ingredient and projected dosage.

Where classic diseases are not arrested, the Contractor shall replace the plants at his own expense. He shall be held responsible for any eventual damage caused to neighbouring plants. In case of an error in handling and spreading herbicides and pest control products, replacement and reinstatement of plants shall be at no additional cost to the Employer.

Pesticides

The Contractor shall take necessary measures to preserve plants from insects and cryptogamic diseases. Clearing of caterpillars shall be made by spraying pesticides after cutting and burning cocoons.

Pesticides nature and dosage shall be approved by the Engineer before application. The Contractor shall be the sole responsible for the use of such products.

219.6.4 Lawn Maintenance

Lawn mowing

Mowing frequency and height shall be decided with the Engineer in terms of the grass growth rate. The mowing height shall not exceed 8 cm. Lawn can be mowed once or several times depending on the weather conditions.

Lawn mowing shall be carried out by any appropriate means. Mower blades shall be sharpened to make a sharp and clean cut. Before mowing, lawned surfaces shall be cleaned and cleared from all debris. Mowing shall be done in a straight line.

Mowing includes :

- the clean cutting of lawned surfaces bordering shrubs
- use of mowers operated manually or powered by light engines to cut the grass at the foot of trees
- mowing of paths and tiled floors borders, around manholes, etc ...

The use of Graminaceae growth reducing products is prohibited. Lawn clippings shall be removed.

Rolling and leveling

The soil shall be rolled - when necessary - after, but never during, thawing. The soil should be slightly humid.

Selective chemical herbicides

Once a year, in May, when temperature is not very high and wind is moderate, lawns shall be treated with a selective chemical herbicide containing 2.4 D with 2.4 MCPA, Dicamba or Mecoprop.

Lawn mowing shall be stopped four days before treatment and resumed eight days thereafter.

219.6.5 Fertilization

(Starting from the second year of maintenance).

(a) Soil tests

Soil tests shall be conducted every year, in the beginning of the gardening season to determine the required additional nutrients and the seasonal fertilizers applications.

Such tests are conducted by an approved agronomic soils testing laboratory.

(b) Trees and conifers fertilization

Nitrogen slow release compound fertilizers shall be used. Such fertilizers shall be spread twice a year with a mean dosage equal to 1 kg/tree/fertilization. Such dosage shall be calculated following to the soil tests.

(c) Shrubs fertilization

Nitrogen slow release compound fertilizers shall be used. Fertilizers shall be spread twice a year. Dosages shall be calculated upon the soil tests results and according to plantation density.

(d) Lawn fertilization

Nitrogen slow release compound fertilizers shall be used twice a year to compensate for lawn mowing (600 kg/ha approximately).

The recommended schedule for spreading fertilizers is :

- April (after natural growth of lawn)
- September (outside very hot season).

Fertilizers shall be spread by means of a rotary tiller fitted with a seed spreader. However, according to planted areas and loads, fertilizers may be spread manually.

Immediately, after fertilization lawned surfaces shall be watered.

220 - MISCELLANEOUS SITE WORKS

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220 MISCELLANEOUS SITE WORKS

220.1 SCOPE

The provisions of this Chapter shall apply to the following kinds of site works:

– Fencing, including gates and wickets,
– Grassing,
– Roads and paved areas.

Other kinds of site works, if required, will be detailed in the Particular Specification.

220.2 FENCING, GATES AND WICKETS

Wherever shown on the Drawings or directed by the Engineer, the Contractor shall erect fences, gates and wickets. All fences, gates and wickets shall be in accordance with the layout and details shown on the Drawings and/or described in the Particular Specification.

The ground along the fence alignment shall be levelled so as to provide an even gap between the bottom wire and the ground surface.

All main and tie wires, all barbed wires and all other metal parts shall be hot-dip galvanized, unless otherwise specified or directed. The fence shall be stretched and fastened by means of approved fasteners, to the satisfaction of the Engineer. Stretching shall not be commenced until the concrete foundations have sufficiently hardened and in no case before 14 days from the pouring of the foundations.

Unless otherwise specified or directed, the entrance gates shall be double leaf and wickets single leaf, to the widths and heights shown on the Drawings, fabricated form standard galvanized water pipe and fittings including bracing, and covered with 5 x 5 cm wire mesh made of 3 mm diameter galvanized and plastic coated wire. The gates shall be hinged to gateposts and shall be complete with locks and stops. All wires and metal parts shall be hot-dip galvanized, unless otherwise specified or directed.

Wherever called for on the Drawings or in the Particular Specification, painting shall be carried out in accordance with Subsection 207.1.5.

Fences shall be measured for payment in linear meters of finished fence, as shown on the Drawings. Gates and wickets shall be paid for per unit. The rates under this Section shall include for all materials, equipment and labour required to complete the fences, gates and wickets in place, in accordance with the Drawings and Specification, and to the satisfaction of the Engineer.

220.3 GRASSING

Wherever specified or directed by the Engineer, the slopes of earth embankments shall be grassed. Areas to be grassed shall, unless otherwise specified, be covered with a layer of productive topsoil of 15 cm thickness, obtained form stripping as specified in Subsection 201.2.3 above. This topsoil shall be a fine sifted soil or silt, not less than 15 cm compacted

thickness, and shall be raked and brought to a fine tilth. Should the stripped material be insufficient or, in the Engineer's opinion, unsuitable for grassing, the Contractor shall supply approved material for this purpose.

Grass shall be a tough, deep-rooted, hardy, local grass, approved by the Engineer. The grass shall be planted in adjacent, parallel, horizontal lines, not more than 20 cm apart. Tussock dibbling with bunches of grass roots will not be permitted. The grass shall be carefully maintained, watered and cut, until a good, healthy growth has been assured and the grass has spread all over the surface. Any roots washed out by rain water, or dead roots, shall be replaced at the Contractor's own expense. Manure and/or ammonium Sulfate shall be used to promote growth, where this is backward.

Grassing shall be measured for payment by square meters of grassed surface, as shown on Drawings. The unit rate shall include the preparation of the protective topsoil layer, planting of grass and its maintenance, cutting, watering and fertilizing, as specified above. The cost of supply and spreading of topsoil obtained from stripping shall be included in the payment for stripping, in accordance with Subsection 201.2.3, and shall not be paid for under this Subsection.

PART 3

MECHANICAL WORKS

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301. GENERAL MECHANICAL SPECIFICATION REQUIREMENTS

301.1 ABBREVIATIONS

The following abbreviations are used in these documents :

1/head/day	liters per head per day
AC	Asbestos Cement
AGMA	American Gear Manufacturer's Association
AOD	Above ordnance datum
BS	British Standard
CDR	Council for Development and Reconstruction.
CFM	cubic feet per minute
Ch	Chainage
CMR	Continuos Maximum Rating
CP	Code of Practice
CPU	Central Processing Unit
DI	Ductile Iron
DIN	Deutsch Industrie Normen
DOV	Double Orifice Valve
DPSK	Differential Phase Shift Keying
DTU	Documents Techniques Unifiés
EDL	Electricity of Lebanon
EMC	Electromagnetic Compatibility
EOH	End of hole.
FDS	Functional Design Specification
FIDIC	Federation Internationale des Ingénieurs- Conseils
FSK	Frequency Shift Keying
g	acceleration due to gravity ($9.807 m/s^2$)
GL	Ground level
gpm	gallons per minute
gr	gram
GRP	Glass Reinforced Plastic
GTSD	General Technical Specification Document
hr	hour
I/O	Input / Output
IEE	Institute of Electrical Engineer
ISO	International Standards Organization
ITS	Institute of Technical Studies
kgf	kilogram force
kPa	kilo Pascal
kVA	kilovolt-ampere
kW	kilowatts
kWh	kilowatt hour
LED	Light Emanating Diode
m	meters
m/s^2	meters per second per second
m^3	cubic meters
m^3/day	cubic meters per day
MDPE	Medium Density Polyethylene
mgd	million gallons per day

mhd	meters head
mm	millimeters
NFE	Normes Françaises - (Electrical)
NLQ	Near Letter Quality
NPSH	Net Positive Suction Head
PS	Particular Specification
PTT	Poste de Téléphone et de Télégraphe
PVC	Polyvinyl Chloride
PWL	Pumping Water Level
RAM	Random Access Memory
RBC	Rotating Biological Contractor
RTR	Reinforced Thermoplastic Resin
RTU	Remote Terminal Unit
SCADA	System Control And Data Acquisition
SOV	Single Orifice Valve
SPTD	Signal Pole Double Throw
SSU	System Supervisory Unit
SWL	Static Water Level
TDH	Total Dynamic Head
TDM	Time Division Multiplex
TEFC	Totally Enclosed Fan Cooled
UHF	Ultra High Frequency
UPS	Uninterrupted Power Supply
UPVE	Unsaturated Polyvinyl Chloride
VDU	Video Display Unit
VGA	Video Graphics Array
VHF	Very High Frequency
VHS	Video Home System

301.2 GENERAL

The following clauses shall specify general mechanical requirements and standards of workmanship for equipment and installations. These general specification clauses shall apply where appropriate except where particularly redefined in the individual sections of the specification.

301.3 FINISH

All covers, flanges and joints shall be properly faced, bored, fitted, hollowed, mounted or chamfered as the case may be, according to the best approved practice and all working parts of the plant and other apparatus, shall similarly be well and accurately fitted, finished, fixed and adjusted.

301.4 CALCULATIONS AND CONSTRAINTS

All parts shall be designed according to the most unfavorable conditions they might encounter during operation, the international regulations and standards and the specifications of the present tender document.

Parts shall be oversized and designed to withstand maximal strains and pressures occuring during operation; ensure a good anchorage and a perfect distribution of strains, and withstand dynamic stresses, untimely shut downs, etc...

Mechanical parts shall have a safety coefficient under normal working conditions of minimum 5 according to the breaking load of the metal used (provided that the adopted international standards do not impose another coefficient).

Welded parts likely to undergo great stresses shall be annealed.

Flanges and bolting materials shall be oversized and shall not generate, when used, elastic lengthenings incompatible with the sealing of the assemblings.

301.5 ASSEMBLING AND DISASSEMBLING

Assembling and disassembling for usual maintenance purposes shall be made as easy as possible, without having to modify any part of the structure. Thus, all junctions and branchings of pipes which diameter exceeds 2"1/2, with bends, T-joints and the like, shall be made exclusively by means of flanges and/or removable couplings, if need be.

301.6 GENERAL GUARANTEES AGAINST WEAR

The Contractor shall acknowledge the condition of the water used, and that, under normal working conditions, the supplied equipment shall not show any abnormal sign of wear.

Main elements subject to significant wear due to water, shall be fitted with removable parts. These elements and parts, shall be made from a resistant metal.

301.7 LIFESPAN

Equipment, especially outdoor plants shall be resistant to physical and chemical phenomena likely to reduce their lifespan.

Following are the main phenomena to be taken into consideration :

301.7.1 Oxydation

When selecting and using the materials and components of the equipment, the following conditions shall be taken into account :

– All sets of screws shall be coated with cadmium, bichromate, or zinc.

- Metalworks shall be of bronze, brass, copper alloy. Connections between metalworks and supports are designed to prevent any corrosion.
- The use of inflammable moulded plastic materials is permitted for small sets (small boxes, telephones, etc....) which do not undergo mechanical or thermal stresses.
- Electrical equipment shall be fixed on galvanized and painted iron mounts, frameworks or runs.
- Protection sleeves are of aluminium
- Gratings shall be hot dip galvanized
- Electrical equipment and components shall be internally and externally tropicalized.

Insulators of electrical equipment, and wedging and securing devices shall be of isolation class F, (unless otherwise specified). The windings shall have a vacuum double coating for tropicalized treatment.

It shall not be permitted to use any hygroscopic or likely to mould material, namely, cotton, asbestos, bakelite, shellac, natural rubber.

- Dielectric oil of machines shall not be put in direct contact with air.
- The use of heat resistances is mandatory in installed boxes and switchboards (condensation).
- Precautions shall be taken in order to avoid oxydation during transport and on site storage of the equipment. Packings suitable for sea transport, protective paintings or coatings and other means (terminals or cable ends weldings, tips or caps of pipes,...) must be used.

301.7.2 Corrosion caused by water

Equipment, in contact with water, shall be of metals and alloys, which nature, physical and chemical characteristics and conditions of use are capable to withstand corrosion of water.

Complementary measures of mechanical, chemical, and electrochemical protections (coating with paint, plastic deposit, zinc, or electrolytic cells) shall be taken, when selecting materials.

Cast iron parts, as long as the use of this material is permitted, shall be protected by a special coating in order to avoid graphitization.

Steel parts shall be coated, preferably, with an appropriate alloy.

301.7.3 Temperature

Materials - in particular insulators and couplings - shall be chosen to ensure a good mechanical lifespan, regardless of the temperature, the mechanical constraints and the temperature gradients due to their operation or the climatic conditions.

301.7.4 Heating

Temperature of bearings, reducers, and other mechanical parts shall not exceed 80°C during normal operation.

Electrical insulating materials shall not be subject to heating exceeding that of class B.

301.7.5 Dirt

Heat exchangers, coolers, etc... shall be calculated with a 5% margin on the surfaces. The maximum proportion of dirt corresponds to 15% decrease in the exchange coefficient.

301.7.6 Adverse weather

Installed equipment and machinery shall be designed to prevent any penetration, accumulation, water impregnation or encrustation caused by air or water entrained products (dust, sand, earth, ashes, vegetal detritus, insects, etc...)

Slopes and flows are designed accordingly.

Electrical, electronic or mechanical equipment, which cannot withstand adverse weather, shall be installed indoors, inside switchboards or boxes impervious to water jets and dust, and fitted with ventilation holes and necessary heating or ventilation means.

The external protective coating for pipes, valves and fittings or equipment shall be designed to be impervious to rain and water jets, without impeding dissassembling for inspection or maintenance purposes.

Great care shall be taken to ensure the sealing of bearings, pipes, casings, sheaths, electrical plugs, probes, and junctions. No leak is permissible.

Seal packings shall preserve their quality regardless of the temperature, temperature gradients, and industrial lubricants they are subject to.

Sliding surfaces, whether greased or not, shall be protected to prevent dust deposits which may cause plugging.

301.8 FOUNDATIONS, BUILDERS WORK AND SETTING OF MACHINERY

The Contractor shall ensure that the positions of foundations for machinery plinths, holding-down bolts and the setting of machinery are carried out in accordance with the approved machinery drawings and shall be held responsible for the accuracy of the particulars given thereon.

The Contractor shall, upon receipt of the necessary approved drawings for the machinery, supervise the construction of all the necessary foundations and bases for the various items of plant, including the forming of holes and chases for pipework, cabling, conduit, ragbolts and where necessary, the building in of foundation bolts and sundry items of plant, all in accordance with the drawings. Spaces shall be left between the concrete and bedplates etc. for grouting and building in. The Contractor shall provide all necessary templates for fixing the positions of bolt holes, etc.

The machinery shall be mounted on flat steel packings of a thickness selected to take up variations in the level of the concrete foundations.

The packings shall be bedded by chipping or grinding of the concrete surface.

Only one packing of selected thickness shall be used at each location, which shall be adjacent to each holding down bolt. The number of shims shall not exceed two at each location and the thickness of each shim shall not exceed 3 mm.

The machinery shall be aligned, leveled and pulled down by the nuts of the holding down bolts with a spanner of normal length, and no grout shall be applied until the machinery has been run and checked by the Engineer for stability and vibration.

The Contractor shall clean the concrete and prepare for grouting up after the pumps, motors, girders, etc., have been finally fixed and packed up.

The Contractor shall supervise the grouting and building in of the equipment and shall take all responsibility for the satisfactory nature of this work.

The Contractor shall arrange for the delivery of all items of equipment that are required to be "built in" the civil works, as required by the construction program and shall arrange for a representative to be in attendance during the progress of such works.

When the foundations are completed and are in a suitable condition or when directed by the Engineer, the Contractor shall install the plant, which when leveled-up shall be grouted, by the Civil Contractor, to the Contractors instructions.

301.9 LOCATION AND ALIGNMENT

Where separate items of interconnected plant, such as motors, couplings, gearboxes and similar items depend upon correct alignment for satisfactory operation, then each and every item shall be positively located in its correct operational position by means of dowels, locating pins, fitted bolts or other approved means to ensure that correct re-alignment can be easily achieved when re-assembling the items after removal for overhauls.

301.10 FASTENINGS TO CONCRETE OR MASONRY

Anchor bolts for the fixing of small items shall be of the torque-expanded type of approved make, installed strictly in accordance with the manufacturer's instructions. The size of hole required in the Civil work shall not exceed 38mm.

Where the base material will not withstand the expansion stresses imposed by the torque-expanded type or where the highest degree of resistance to vibration is required an approved type of chemically bonded anchor bolt may be used.

The minimum distance from any concrete edge shall be 100mm for expanding type fixings and 75mm for embedded bolts.

301.11 BASEPLATES

Separately mounted items of plant which are required to maintain an accurate alignment shall be mounted on a common baseplate, together with all associated items and guards.

The baseplate shall be of rigid construction, machined on all mating surfaces and drilled for foundation fixings. Machined datum faces shall be provided and levelling facilities incorporated in the underside.

Provision shall be made for the easy removal of any section of the drive and positive re-alignment using dowels or other approved means. Shims and packings shall be kept to a minimum and clearly identified for re-assembly.

All drain points on the assembled plant are to have easy access and drain piping shall extend beyond the baseplate.

301.12 PROVISION FOR HANDLING

Suitable provision approved by the Engineer shall be made by the Contractor to facilitate the handling of all items in excess of 36kgf.

Any item weighing one tonne or over and which may be required to be lifted during operation and maintenance shall be appropriately marked with its weight.

301.13 GUARDS

Adequate guards shall be supplied and installed throughout the installation to cover drive mechanism. All rotating and reciprocating parts, drive belts, etc. shall be securely shrouded to the satisfaction of the Engineer to ensure the complete safety for both maintenance and operating personnel. However, whilst all such guards shall be of adequate and substantial construction they shall also be readily removable for gaining access to the plant without the need for first removing or displacing any major item of plant.

301.14 BALANCING

All rotating parts of the machinery shall be statically and dynamically balanced unless otherwise agreed in writing by the Engineer. The complete rotating assembly shall be designed such that any critical speeds are outside the duty running speed range of the machine.

301.15 LUBRICATION

Any components requiring manual lubrication shall be provided with greasing nipples of an approved type mounted on a panel and identified.

A remotely mounted electrically operated lubricator of approved type shall be provided to serve components, if any, requiring continuous lubrication by external mechanical means.

The lubrication tubes, if any, shall be of approved material suitable for high pressure use.

The Contractor shall include for all grease and oil required for testing at works and site.

The first filling after tests shall be provided by the Contractor who shall submit details of his recommended lubricants, which shall be available from any of the major oil companies, for approval by the Engineer.

All bearing surfaces shall be properly charged with grease before the plant is operated.

301.16 NAMEPLATES AND LABELS

Instruction plates, nameplates and labels shall be provided for all items of the plant giving particulars of duty, size, serial number and full information for identification and operation. Their construction and engraving shall be to the Engineer's approval.

301.17 PLANT REFERENCES

After final painting, all plant items shall be identified by a unique reference character as detailed on the specification drawings or otherwise specified. Such references to be affixed in a prominent position on the plant body with characters not less than 100mm high or as otherwise specified. Characters shall be bold capital letters and/or numerals. The abbreviation `No' shall not be used.

Unit references shall include any associated main and auxiliary drives and shall follow a logical sequence based on layout or history. In any particular installation, a set of similar duty drives where any number of units may run shall be suffixed 1, 2, 3, 4 etc., whereas alternative drives for the same duty where only one unit may run (ie.duty/standby) shall be suffixed A & B.

301.18 TOOLS AND TACKLE FOR MAINTENANCE

The Contractor shall supply a complete set of any special tools and other equipment necessary for the dismantling, re-erection and adjustment of the plant.

The tools provided shall be in new condition, adequately labelled as to their use and contained in stout and suitable padlocked boxes. The Engineer's instructions as to who shall be the recipient of the tools shall be sought before delivery is made.

Any special slings required shall be provided and clearly marked by embossed labels to show safe working loads. Test certificates shall be provided where applicable.

301.19 LOCKS AND KEYS FOR MECHANICAL PLANT

All locks of the same size shall be of the same type and manufacture but having different keys.

Three keys shall be provided for each lock.

Each key shall have permanently attached to it an embossed brass label stating the following:

a) Key number
b) Location of lock/Item of equipment

301.20 NOISE AND VIBRATION

All plant shall run with the least practicable amount of noise. The contact shall insulate the material when necessary.

All plant shall run without undue vibration. All parts supplied shall be designed such that when being used, opened or partially opened (under normal operating conditions) the dynamic stresses shall not cause any vibration, nor deformation.

Vibration levels shall not exceed these set cut in ISO 2372 for the particular type of equipment.

The double amplitude on the bearings shall not exceed 20 microns under normal working conditions.

Analytical and safety instruments, as well as control mechanisms shall be systematically protected from vibrations, and when necessary, installed far from machines (on independent support or panels). Particular precautions shall be taken in the event of a relay likely to lead untimely opening and closing of electrical contacts.

The equipment supplied shall never cause any vibration in masonries. Machines shall operate as quietly as possible.

To meet the environmental requirements, the Contractor shall provide all necessary equipment to meet the following conditions, based on the site layout shown on the specification drawings and with 75% of the plant running simultaneously:

a) the noise level generated at the site boundary by any new plant shall not exceed that generated by the existing plant, or the maximum background noise measured between 12 p.m. and 4 a.m. plus 5 dB. Background noise is defined as being the L_{A90} level, that is the level exceeded for 90% of the measurement period.

b) Warning notices shall be provided at all entrances to rooms where the noise level will exceed 75 dB (A).

301.21 BEARINGS AND LUBRICATORS

Ball and roller bearings shall be rated for a minimum plant life of 10 years, with due consideration being given to the number of starts and periods of operating under conditions of maximum dynamic axial and radial loading. The size of bearing shall be not less than that calculated for a minimum L10 basic rating life in accordance with BS.5512 Part 1.

Taking into account all considerations of reliability, materials of manufacture and operating conditions.

All bearings shall be generously rated and sized to ensure satisfactory and stable running without vibration under all conditions of operation for a minimum life of 100.000 hours running. They shall be efficiently lubricated and adequately protected from ingress of moisture, dust and sand and the particular climatic conditions prevalent at the site. All bearings shall be to ISO standard SI unit dimension where practicable.

All ball or roller bearings, including those supplied as "sealed for life" shall be arranged for grease gun lubrication and a suitable high pressure grease gun shall be supplied. All grease nipples shall be standardised.

Adequate and as far as possible, automatic means of lubrication shall be provided for all moving parts. The position of all greasing and oiling points shall be arranged so as to be readily accessible for routing servicing. Where necessary to achieve this, suitable access platforms shall be provided.

The type of lubricant and intervals of lubrication, which shall be kept to a minimum (not less than nine days), for each individual item of plant shall be entered on a working schedule, which shall form part of the Operation and Maintenance instructions.

A list of recommended lubricants and their equivalents shall be entered in the operation and maintenance instructions.

301.22 FROST PROTECTION

The plant shall be adequately protected against damage from freezing, using an approved means of insulation.

Particular attention shall be given to pipework, pump casings, etc. and any part of the plant and equipment likely to stand for periods charged with static water.

Where lagging is used, it shall be suitable for outside installation and completely impervious to all weather and atmospheric conditions on the works. Lagging materials containing asbestos shall not be used.

The lagging shall be sectional and easily removed for maintenance purposes. Joints shall be sealed together with an approved waterproof adhesive tape.

Areas where lagging may be vulnerable to damage shall be suitably protected by an approved means.

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.

308. FIRE FIGHTING

Portable type fire extinguishers shall be provided as detailed in the Particular Specifications.

The following types of Portable fire extinguishers are used:

All Portable fire extinguishers shall be in accordance with American regulations standard 10-1 and or equivalent European and internationally accepted standards such as BS 6535, 6643 and 5423.

- CO_2 type fire extinguisher (G) of 6 kg complete with hose, H Horn and wall mounting bracket.

- ABCE Powder type fire extinguisher (P) of 12 Kg complete with wall mounting brackets.

- ABCE Powder type on wheels fire extinguisher (PW) of 35 Kg.

- Cylinders shall be of 1.5 mm stamped iron plate of high quality, electric welding under electronic control, red oven painting with epoxy powders, and bursting pressure tested till 80 bars.

- Valves shall conform to European newest standards in stamped brass with safety device.

- Manometer of good quality.

- Rubber hose with working pressure of 20 bar.

- Dry nitrogen propeller.

- Temperature stability $-60^{o}C + 80^{o}C$

- Powder shall be of non toxic during handling and applications and shall be dry and durable for at least 5 years.

309. HEATING VENTILATION & AIR-CONDITIONING

309.1 GENERAL

309.1.1 Technical clauses

Equipment and material shall be of good quality and stored under the best conditions (protected from temperature, sunlight, corrosion...). They shall be stored and sheltered from adverse weather conditions, such as humidity and temperature variations, dirt and dust, or other contaminants.

Transport costs shall be borne by the Contractor. Before ordering, he shall submit samples and catalogues for approval. Equipment shall be installed taking into consideration the manufacturer recommendations to ensure proper access, operation, and maintenance.

Subject to approvals, shop drawings may be modified to meet the requirements of the manufacturer. Materials which are not approved or found not easily accessible for maintenance shall be rejected, replaced and reinstated by the Contractor at his own expense.

309.1.2 Civil works

The Contractor shall be responsible for the coordination of all requirements of other Sections works namely, those of civil engineering and electricity, regarding the provision of openings in masonry or concrete works. In default, he shall perform upon the approval of the Engineer, all piercing, fixing and closing works. Where the Engineer refuses any such work, the Contractor shall not have right to claim for indemnity. Before closing the openings, all ducts, shafts and sleeves shall be covered with an approved resilient material.

309.1.3 Nameplates

Equipment shall have a nameplate that identifies the manufacturer’s name, address, type or style, model or serial number, and catalog number.

309.2 DESIGN CRITERIA

309.2.1 Design conditions

Outside conditions in summer:

92° F (33° C) Dry-bulb temperature
82° F (28° C) Wet-bulb temperature
Inside conditions in summer:

75° F (24° C) Dry-bulb temperature
50% Relative humidity

Outside conditions in winter

40° F (4° C) Dry-bulb temperature

Inside conditions in winter

68° F (20° C) Dry-bulb temperature

The noise level from evaporation machines and air extractor, measured at 1.5 m from any grille should not exceed 40 dBA.

Where this level is exceeded, sound attenuators shall be installed by the Contractor at his own expense.

Windows shall be 6 mm thick single-glazed or double glazed as per the project requirements.

309.2.2 Design cooling capacities

Air Cooled A/C equipment must give the required duty when the air temperature entering the condenser is equal to the specified design outside summer dry bulb temperature unless the specifications call for higher temperature for special applications. In addition, the equipment shall continue to function satisfactorily withou tripping or overheating at a maximum outside dry bulb temperature 40° C.

309.2.3 Accepted standards

The following standards are accepted for ACHVR services provided that necessary corrections and provisions are made to suit local climatological and design conditions, power supply system and other required codes.
ASHRAE: American Society of Heating Refrigeration and Air Conditioning Engineers (U.S.A)

IHVE : The Institute of Heating and Ventilation Engineers (U.K.)
ASME : American Society of Mechanical Engineers.
ARI : Air Conditioning Refrigeration Institute (U.S.A.)
ASTM : American Society for Testing and Materials.
AWS : American Welding Society.
UL : Underwriter Laboratories (U.S.A.)
SMACNA: Sheet Metal and Airconditioning Contractors National Association, Vienna.
HVCA : Heating and Ventilation Contractor’s Association, U.K.

ADC 1062:GRD (1984) Test Codes for Grilles, Registers and Diffusers

AIR MOVEMENT AND CONTROL ASSOCIATION (AMCA)

AMCA 210 (1985) Laboratory Methods of Testing Fans for Rating

AMCA 300 (1985; REV 1987; errata) Reverberant Room Method for Sound Testing of Fans

ASTMD1654 (1992) Evaluation of Painted or Coated Specimens Subjected to

	Corrosive Environments
ASHRAE 52	(1968; R 1976) Air-cleaning Devices Used in General Ventilation for removing Particulate Matter
ASHRAE 68	(1986) Laboratory Method of Testing

Other International Standards may be considered provided they meet with the above standards as a minimum.

309.3 EQUIPMENT AND INSTALLATION

309.3.1 Split system heat pump

309.3.1.1 General

Air conditioners shall be of split system heat pumps type. The evaporators shall be installed on the mezzanine and/or on the roof. Condenser units shall be roof mounted.

309.3.1.2 Evaporator

It shall include:

- Heat exchanger with copper tubes and aluminium fins tested under 21 bars at the factory
- Expansion valve
- Balanced centrifugal fan, multi-speed installed on life-greased bearings
- washable metalic 25 mm thick filter, 90% arrestance of all particles down to 3 microns with an outside lable indicating danger of inflammability.
- Insulated stainless steel drain tray (sloped toward drain pipe) to receive condensates.

The system shall be installed in a metallic casing of thick sheet steel protected with two coats of baked paint and internally lined with fibreglass of suitable thickness.

309.3.1.3 Condensing unit

It shall include:

- Hermetic compressor with stop valve at the suction and the discharge, mounted on antivibration pads in a technical enclosure. The compressor shall be of gas suction cooled type

- Condenser coil made of drawn copper tubes, with aluminium fins and a liquid line solenoid valve. Aluminium fins shall be treated by cataphoresis: scouring, rinsing, deoxydation then rinsing, phosphate crystal coating, bonderising, black or grey electrolytic cataphoresis paint, ultra filtering rinsing with demineralized water

- Expansion valve

- Fan with protection grille

– Shock resistant bottle.

The assembly shall be installed in a perforated casing. The metal jacket shall be of galvanized sheet treated with phosphate, and of suitable thickness. It shall be protected with two coats of baked paint.

Motors winding shall be thermally and electrically protected and weatherproof.

Control circuit shall include a time-delay relay and an electric protection for the compressor, a phase failure detector (loss of one phase or reverse phasing) for the three-phase motor, high and low pressure switches, a relay for the fan and a relay for the evaporator.

309.3.1.4 Refrigerant pipes

Refrigerant pipes between the evaporation and the condenser shall be hard copper, L type, insulated with Isoflex expanded synthetic rubber. Refrigerant pipes shall be soldered by nitrogen. Length of refrigerant pipes shall be carefully selected in relation with the units.

309.3.1.5 Control and electric connection

Cables and electric equipment shall be installed as specified in their relevant sections.

Control and electric connections shall include:

– A seasonal winter/summer thermostat with a selector switch: ON-OFF-VENTILATION. Thermostat shall be of remote bulbs type

– A circuit-breaker

– A control circuit between the evaporator and the condensing unit. Control cables shall be multicores, NYM type or equivalent

– All equipment shall be fitted with double insulated transformer allowing supply of the control circuit. The main power supply shall be three-phase. The Contractor shall be responsible for the installation of electric cables starting from the circuit breaker.

309.3.1.6 Installation

The evaporator shall be mounted on neoprene anti-vibration pads installed on U bars secured to the ceiling.

The condenser shall be mounted on neoprene anti-vibration pads. The drain pipe shall be PVC with a P-trap with 50 mm high waterseal.

The blower shall be connected to the duct by a 20 cm wide thick flexible duct.

Blower noise level shall not exceed 40 dBA when measured at a distance of 1 meter from the supply and return grilles. Blowers shall be fitted at the discharge with sound attenuators.

Roof-mounted evaporators shall be installed in a 150 cm high room. The room will house all supply and return ducts. Openings of supply and return ducts in the roof slab shall be accessible and weatherproof.

Free surface as per manufacturers recommendations shall be arranged around the evaporator for maintenance.

Waterproofing shall be ensured around ducts with metallic filler band.

309.3.2 Decorative air conditioners

309.3.2.1 General

Decorative air conditioners shall be of split system heat pump type. Evaporators and condensing units shall be wall mounted.

309.3.2.2 Evaporator

It shall include:

- Heat exchanger with copper tubes and aluminium fins tested under 21 bars at the factory
- Fan with tangential turbine with directional radial flow. Motor shall be of the silent type mounted on elastic suspensions and fitted with internal protections
- Air cartridge filter mounted on sliding guides and accessible from the front panel: 90% arrestance of all particules down to 3 microns
- Supply grille consisting of an adjustable multi-directional deflector
- Insulated stainless sheet steel drain tray to receive condensates

The casing shall have a polystyrene front and a stove enamelled steel backplate.

309.3.2.3 Condensing unit

The condensing unit will house the refrigerant compressor, the condenser, the moto-fan group, the expansion valve, as well as the electrical equipment.

- A hermetic compressor, mounted on antivibration pads in a technical compartment, fitted with a shock resistant bottle of gas suction cooled type. Stop valves shall be placed at the suction and at the discharge.
- A condenser coil made of drawn copper tubes with aluminium fins and fitted with a liquid liner solenoid valve.
  Aluminium fins shall be treated by cataphoresis: scouring, rinsing, deoxydation then rinsing, phosphate coating, bonderising, black or grey electrolytic cataphoresis paint, ultra filtering rinsing with demineralized water.
- A helicoidal fan with axial flow and low rotating speed and fitted with a protection grille, a motor of the silent type and shall be thermally and electrically protected.

– The casing shall be weatherproof and the compressor shall be placed in a soundproof compartment.

– Control circuit shall always include high and low pressure cutout switches, a relay for the fan, a relay for the evaporator and a time-delay relay for the compressor.

309.3.2.4 Refrigerant pipes

Refrigerant pipes between condensing unit and evaporator shall be precharged and delivered with the unit.

Refrigerant pipes shall have ends fitted with automatic wedge coupling. Length of refrigerant pipes shall be considered when selecting the units.

309.3.2.5 Control and electric connection

Cables and electric equipment shall be installed as specified in the relevant Seciton “Electrical Installations”.

Control and electric connections shall include:

– A seasonal summer / winter thermostat with a selector switch: ON-OFF-VENTILATION-COLD-HOT

– A three position velocity controller

– A circuit-breaker

– A control circuit between the evaporator and the condensing unit. Control cables shall be multicore, NYM type or equivalent

– Equipment shall be fitted with a double insulated transformer for the supply of the control circuit

– The main power supply shall be single-phase

– The Contractor shall be responsible for the installation of electric cables starting from the circuit-breaker.

309.3.2.6 Installation

The condensing unit shall be installed on neoprene antivibration pads and supported by a metal frame.

PVC drain pipes shall be used.

Operating noise level of evaporator shall not exceed 40 dBA when measured at a distance of 1 meter from the unit.

309.3.3 Roof top packaged A/C unit

309.3.3.1 General

The units shall be of the horizontal airflow with 40° C and 4°C in cooling as standard from the factory for all units. Cooling performance shall be as shown on drawings. All units shall be factory assembled, internally wired, fully charged with R-22 and 100 percent run tested to check cooling operation, fan and blower rotation and control sequence, before leaving the factory. Wiring internal to the unit shall be colored and numbered for simplified identification.

309.3.3.2 Casing

Unit casing shall be constructed of zinc coated, heavy gauge, galvanized stee. All components shall be mounted in a weather resistant steel cabinet with a painted exterior. Cabinet construction shall allow for all maintenance on one side of the unit. Service panels shall have lifting handles and shall be easily removed and reinstalled providing a water and air tight seal. The indoor air section shall be completely insulated with fire resistant permanent, odorless glass fiber material. The base of the unit shall have provisions for forkliff and crage lifting.

309.3.3.3 Filters

Two inches metalic washable filters on filter rack.

309.3.3.4 Compressors

A minimum of two compressors, shall be direct drive hermetic, reciprocating type with separate centrifugal oil pump providing positive lubrication to moving parts, motors shall be suction gas-cooled and shall have a voltage utilization range of plus or minus 10 percent of unit nameplate voltage. Crankcase heater, internal temperature and current-sensitive motor overloads shall be included for maximum protection. Compressors shall have internal spring isolation and sound muffling to minimize vibration transmission and noise. External high pressure cutout, discharge temperature limit, winding temperature limit and compressor overload shall be provided.

309.3.3.5 Refrigerant Circuits

Two independant refrigerant circuit each shall have independent fixed orifice expansion devices, service pressure ports and refrigerant line filter driers factor installed as standard. An area shall be provided for replacement suction line driers.

309.3.3.6 Evaporator and Condenser Coils

internally finned 3/8” copper tubes mechanically bonded to configured aluminum plate fin shall be standard. Coils shall be leak tested at the factory to ensure the pressure integrity. The evaporator coil and condenser coil shall be leak tested to 200 psig and pressure tested to 450 psig.

309.3.3.7 Outdoor fans

The outdoor fans shall be direct drive statically and dynamically balanced, draw through in the vertical discharge position. The fan motor(s) shall be permanently lubricated and have built-in thermal overload protection.

309.3.3.8 Indoor fan

Units shall have belt driven, FC centrifugal fans with adjustable motor sheaves and adjustment of fan belts and motor sheaves. All motors shall be thermally protected units shall be capable of providing 1” esp at nominal unit cfm.

309.3.3.9 Controls

Unit shall be completely factory wired with necessary controls and contactor pressure lugs or terminal block for power wiring. Units shall provide an external location for mounting fused disconnect device. Microprocessor controls shall be provided for all 24 volt control functions. The resident control unit shall make all cooling and/or ventilating decisions in response to electronic signals from sensors measuring indoor and outdoor temperatures. The control unit maintains accurate temperature control, minimizes drift from set point and provides better building comfort. A centralized Microprocessor shall provide anti-short cycle timing and time delay between compressors to provide a higher level of machine protection.

309.3.3.10 Electric heaters

Electric heat modules shall be available for installation within basic unit. Electric heater elements shall be constructed of heavy-duty nickel chromium elements internally wye connected for 400 volt. Staging shall be achieved through the unitary control processor (3 stages). Each heater package shall have automatically reset high limit control operating through heating element contactors. All heaters shall be individually fused from factory. The unit shall be equiped with a remote type control box installed as shown on drawings at 1.5 m above flow level having a thermostat. OFF/FAN/COOL and speed selection switch.

309.3.4 Electric convector heaters

Electric convector heaters shall be suitable for domestic and commercial application and shall be fabricated from a self-extinguishing material. They shall be fan assisted and suitable for wall or floor mounting. They shall be protected by a thermal overload device. Their controls shall include a 24 hour timer, frost thermostat (4^{o}C) and variable heat settings.

309.4 AIR FANS

309.4.1 General

Fans shall be tested and rated according to AMCA 210. Fans may be connected to the motors either directly or indirectly with V-belt drive. V-belt drives shall be designed for not less than 150 percent of the connected driving capacity. Motor sheaves shall be fixed pitch as defined by ARI Guideline D. When fixed pitch sheaves are furnished, a replaceable sheave shall be provided when needed to achieve system air balance. Motors for V-belt drives shall be provided with adjustable rails or bases. Removable metal guards shall be provided for all exposed V-belt drives, and speed-test openings shall be provided at the center of all rotating shafts. Fans shall be provided with personnel screens or guards on both suction and supply ends, except that the screens need not be provided, unless otherwise indicated, where ducts are connected to the fan. Fan and motor assemblies shall be provided with vibration-isolation supports or mountings. Vibration-isolation units shall be standard products with published loading ratings. Each fan shall be selected to produce the capacity required at the fan static pressure indicated. Sound power level shall be as indicated. The sound power level values shall be obtained according to AMCA 300. Standard AMCA arrangement, rotation, and discharge shall be as indicated.

309.4.2 Axial Duct Mounted Fans

309.4.2.1 General

Fan Casing shall be cylindrical in construction, with matching metric spirally wound ductwork. Manufactured in heavy gauge galvanized steel with corrosion resistant fixings used throughout. Flanges to be quickfit type.

309.4.2.2 Fan/Motor assembly

Impeller to be of high performance aerofoil type comprising a cast aluminum hub with either aluminum alloy or polypropylene blades. Motors to be manufactured to BS 5000 with class F insulation and sealed for life bearings. Motors to be pre-wired to an external terminal base through flexible conduit.

309.4.2.3 Accessories

Unit to be complete with two mounting pads, four adjustable feet, foot fixings, two quickfit matching flanges and single bolt self sealing clamping collars, two flexible connectors, matching electronic speed controller, pair of wall mounting brackets, inlet cone and wire guard, antibackdraught damper, converter from quickfit to bolted flanges.

309.4.3 Centrifugal In Line Duct Mounted Fans

309.4.3.1 General

Fan Casing shall be rectangular In sections, manufactured from galvanized steel to BS 2982 1982, of rigid constructions with cut edges turned inward for safety. Circular ruged spigots shall be fitted to both ends of the case. The unit shall be supplied with easy installations fixing brackets attached to the unit by means of a single set screw.

309.4.3.2 Fan/Motor assembly

The Fan assemblies shall in coorporate a directly driven, backward curved centrifugal impellers, powered by single phase 200-240 V 50 HZ motors, and balanced with VDI 2060 class Q2.5 to give quiet and vibration free running. Motor shall be rated for IP55 with insulation to class F. Motor shall have integral thermal overload protection, sealed for life bearings and designed to run at any angle. Fan/Motor assembly shall be able to be withdrawn from its casing and turned through 150° to change air flow direction even after duct connection.

309.4.3.3 Accessories

Unit to be complete with two mounting pads, four adjustable feet, foot fixings, two quickfit matching flanges and single bolt self sealing clamping collars, two flexible connectors, matching electronic speed controller, pair of wall mounting brackets, inlet cone and wire guard, antibackdraught damper, converter from quickfit to bolted flanges.

309.4.4 Kitchen Fume Fans

309.4.4.1 General

Kitchen fume fans shall be either axial or centrifugal duct mounted type suitable for extracting fumes and steam, efficient, and designed for low sound level. Fan shall be complete with flexible duct connectors, backdraught and lower shutters, external grille, electrical speed controller, worm drive clips, vibration isolators.

309.4.4.2 Hood

Kitchen hood shall be of Aluminum with V type grease trap washable filter of 50 mm thick designed for maximum face velocity of 1m/s complete with oil drainage facility and shall be to the engineer approval.

309.4.5 Window / Wall Fans

309.4.5.1 General

Window / wall fans shall be of the axial type that can be installed on window or wall, easy to install, esthetic and very silent, made of injected moulded plastic and rated class II electrical insulation.

309.4.5.2 Motors

Single phase motor, shaded pole type, suitable for 220-240 V, 50HZ, low consumptions fitted with internal thermal protection.

309.4.5.3 Accessories

Speed controller operable throug cord and remote fan switch, back draught shutters, wall fixing Kit, extended duct, and wall grille.

309.4.6 Special Application Axial Flow Fans

309.4.6.1 General

Ventilation fans used in water treatment plant such as in dewatering, chlorination, RAS and primary sludge pumping stations shall be belt driven axial fans suitable for flanged duct mounting for industrial application and extraction of high temperature gas up to 150° C, and corrosive and explosive gases.

Casing shall be made of rolled and electro-welled steel plate. The motor support shall be fitted outside the casing and the impeller support is welded inside. A steel sheet case protects the belt and the bearings. The whole assembly is furnished with gray epoxy paint. The casing is fitted with a spigot port.

309.4.6.2 Impellers / motors

Impellers shall be made in die-cast aluminum in one piece, with airfoil profile fixed blades, dynamically balanced according to ISO 1940 and finished with red epoxy paint. Impeller shall be driven by vee-belt drive. Motors shall be induction asynchronous according to IEC 34-1, 4 poles IP55, class F insulation, ball bearings greased for life, and cooling fan mounted externally on the fan.

309.4.6.3 Accessories

All duct work shall be flanged type complete with gasket sealant, flages, nuts, bolts, and washers, made of corrosive resistant steel coated with gray paint.

309.4.7 Roof Cabinet Twin Fans

309.4.7.1 General

Rectangular unit housing to be manufactured in aluminum allory and to contain a removable fan assembly comprising a directe driven centrifugal fans. Exhaust to discharge vertically through high velocity outlets protected by hinged birdguards, which automatically open under pressure. Units shall be fitted with two fans / motors: one runs, the other standby. Units to be provided with internal isolator and control prewired box. Motorst and fans shall be easily acceassable by removing the top cover sewred into the frame with bolts. Waterproof Frame finished in polyester powder paint.

309.4.7.2 Fan / motor

Fan blades shall be manufactured in aluminium alloy with asymetrical blade spacing, to be dynamically balanced. Motors, manufactured to BS 5000, TEFC, IP55, class F insulation incoorporating greased for life bearings, two speed motor.
Resilent mounting shall be supplied to support the fan and motor assembly on the baseplate to minimise machanical noise and vibration.

309.4.7.3 Accessories

Unit shall be supplied with flanged duct flexible connections on the suction side. Antivibration pads for external mounting of the unit on the concrete base.

Twin Fans Microsave control system utilising extra low voltage interface system. Controller to comprise a control module fitted to the twin fan unit which shall interface with the interface control panel (CP) via (24V) 4 core screened signal cable (0.55 mm^2) PVC coated (240V outer insulation). The ICP shall have a touch sensitive switch to select the fan mode and shall incoorporate coloured L.E.D.'s to in dicate fan and control status and is to include an "OFF" position. The I.C.P. shall be the same size as a surface mounted double gang power socket and the facia plate incoorporating electronics suitable for recessing into a plastic double gang power outlet. I.C.P. shall be manufactured in Fire retardant ABS plastic (VO rated) and installed as shown on drawing (REAF-S).

309.4.8 Roof Axial Cowl Fans

309.4.8.1 General

Fans shall be suitable for roof mounting on purposed made upstand as shown on general standard drawings designed to extract air with a horizontal discharge and with the motor shaft in the vertical position. Housing shall be made in polyester with fiberglass.

309.4.8.2 Impellers / Motors

Impellers made of injection moulded plastic reinforced with chemically anchored fiberglass and or cast aluminium protected with epoxy paints, and dynamically balanced in accordance with ISO 1940.

Motor shall be 4 pole, 2 speed asynchronous squirel cage in die cast aluminium in accordances with IEC 34-1: 220-240 V/ 50HZ single or three phase, class F, IP55 complete with thermal overload protection incoorporated in the winding with connections to the terminal base and greased for life ball bearings.

309.4.8.3 Accessories

Motors shall be provided with backdraught shutters preventing air entry when the fans are switched off.

Remote fan switch room mounted as shown on drawings (FEAF-S).

309.4.9 Centrifugal type power roof ventilators

Fans shall be V-belt driven with backward inclined, non-overloading wheel. Motor compartment housing shall be hinged or removable and weatherproof, constructed of heavy gauge aluminum. Fans shall be provided with birdscreen, disconnect switch, backfraft dampers and roof curb. Motors enclosure shall be explosion-proof type. Lubricated bearings shall be provided. All interior fan components shall be coated with a minimum 5-mil thick of Air Dray Phenol.

309.4.10 Air Filters

Air filters shall be listed according to requirements of UL 900, except high efficiency particulate air filters of 99.97 percent efficiency by the DOP test method shall be as listed under the Label Service and shall meet the requirements of UL 586.

309.4.11 Factory painting

Units which are not of galvanized construction according to ASTM A 123 OR ASTM A 525 shall be factory painted with a corrosion resisting paint finish. Internal and external ferrous metal surfaces shall be cleaned, phosphatised and coated with a paint finish which has been tested according to ASTM B 117, ASTM D 1654 and ASTM D 3359. Evidence of satisfactory paint performance for a minimum of 125 hours for units to be installed indoors and 500 hours for units to be installed outdoors shall be submitted. Rating of failure at the scribe mark shall be not less than 6, average creepage not greater than 1/8 inch. Rating of the inscribed area shall not be less than 10, no failure. On units constructed of galvanized steel which have been welded, exterior surfaces of welds or welds that have burned through from the interior shall receive a final shop docket of zinc-rich protective paint according to MS MIL-P-21035.

309.5 AIR DISTRIBUTION DUCT SYSTEM & DAMPERS

309.5.1 Duct works

All sheet metal ductwork shown on the drawings, specified required for various ventilation systems shall be fabricated and furnished from best quality cold rolled, close annealed, plain finished not salted, galvanised mild steel sheets of soft bending quality specially suitable for air conditioning works. Ducts shall be fabricated, assembled and connected in accordance with following table (applicable to galvanised ducts).

Dimension of Largest side mm	Sheet thickness mm	Transfer Between Joints	Reinforcing At Joints
Up to 400 mm	0.6	Not required	Drive slip
600	0.8	Not required	Pocket lock at 90 cm
800	0.8	Not required	Pocket lock at 90 cm
1000	0.8	40 mm x 40 mm x 4 mm at 90 cm	Pocket lock at 90 cm
1250	1.0	40 mm x 40 mm x 4 mm at 90 cm	Pocket lock at 90 cm
1600	1.0	40 mm x 40 mm x 4 mm at 90 cm	Pocket lock at 90 cm

Note: Sheet metal thicknesses are net minimum acceptable after accounting for manufacturing tolerances and should be as measured on site by a micrometer. Otherwise the next higher thickness indicated shall be provided in order to meet the specified thickness. Exhaust air duct from kitchen shall be manufactured from aluminium sheet with thcikness two gauges heavier than galvanised duct.

All bracing and reinforcement angles shall be made of black steel, properly cleaned from rust and painted with 2 prime coats of antirust red paint prior to installation. Angles shall be carried around all four sides of ducts.

Guiding vanes and deflectors shall be installed as shown on the drawings and where required for good air flow. Unavoidable pipe crossing with ducts, conduits, or structural members, shall be approved by the Engineer before erection.

The penetration shall be through a streamlined tight galvanized sheet sleeve of aerodynamic shape without reducing the cross section area.

All bends shall have a radius equal to 1.5 times the width of the duct. Otherwise, bends shall be right angled with streamlined double deflecting vanes.

Good workmanship air tightness and system cleanliness shall be foremost considerations. The interior of all ducting systems shall be clean before erection and all open ends, which are left as the work progresses, shall be temporarily sealed to prevent the ingress of dirt. Mastic type sealing compound shall be used to make duct joints airtight.

All ducting systems shall be adequately supported and all fittings shall be manufactured and installed in accordance with good practice to minimize air turbulence, noise generation and friction loss. Particular attention shall be paid to the selection and location of an adequate number of dampers of suitable type for flow regulation. Consultation with the system designer is recommended to ensure that the regulating procedures to be carried out at commissioning stage may be achieved.

Sufficient thermometers, test points and access doors shall be provided for commissioning and for operating and maintenance purposes.

Provision shall be made for the possibility of dismantling ducting connections and equipment for servicing/removal and suitable precaution shall be taken to prevent transmission of vibration.

Ductwork shall be adequately braced and stiffened to prevent ‘drumming’. Where insulation incorporates a vapour seal, special care shall be taken to ensure the continuity of that seal and to prevent any damage before hand-over.

All dampers shall be checked to ensure that they are properly installed and that the blades and linkages move freely. Where tight shut-off is required checks shall be carried out to ensure there is no undesirable leakage around damper frames or through the assembly in the closed position.

309.5.2 Volume control dampers (VCD)

Manual volume control dampers shall be provided as shown on the drawings or as required additionally for balancing purposes. The dampers shall have sturdy corrosion resistant construction.

Damper quadrants shall be cast metal type with words ‘OPEN’ and ‘SHUT’ clearly marked in raised letters. All dampers shall have multi-leaf, double skin aerofoil section opposed action blades. Individual blades should not exceed 1200 mm in length or 175 mm in width. Double skin blades shall be made out of minimum 22 gage galvanised steel sheet. Damper frames shall be made out of 16 gage galvanised steel sheet.

Single blade dampers with single skin blade section may be used for damper size upto 300 x 300 mm. Single skin blades shall be fabricated from 18 gage galvanised steel sheet.

The blades shall be securely bolted/riveted to plated steel spindles, the ends of which shall be extended to the outside of the damper frame, each with a groove in line with the blade. Spindles shall be carried in brass or nylon bearings. The control linkage shall be outside the air stream. Shut-off dampers shall incorporate rubber blade edges to minimise leakage past the dampers.

Final position of the quadrant handles after balancing the air system shall be clearly marked.

The location of all concealed fire dampers and volume control dampers shall be indicated.

309.5.3 Fire dampers (FD)

Fire dampers shall be of curtain blades outside airstream dampers are designed to stop the spread of fire through ducts, walls and floors and shall be supplied to exact requirements.

The damper blades shall be precision roll-formed and then interlocked to provide a 'curtain' with an angular, heat deflecting construction. All dampers shall be supplied with two constant force stainless steel closure springs and locking ramps to ensure positive closure. Dampers shall be supplied as standard, with an easy maintenance fusible link for ease of testing and resetting dampers. The link is set to operate at 72°C unless otherwise stated.

The fire dampers shall be manufactured as standard from corrosion resistant galvanised mild stee. Should offers superior fire performance characteristics.

The fire dampers shall be designed in accordance with BS476 Part 8 (2 hour rating) and tested and approved.

Units of this type are factory assembled ready for site installation. They shall be supplied complete with installation frames.

309.5.4 Grilles and diffusers (SCD/RCD/ECD/SWG/RWG/EAG)

Grilles and diffusers shall be of rugged construction and made of anodized aluminium with removable cores, turning vanes and volume control dampers for final fine control.

Prior to installation, their location shall be approved by the Engineer and shown on shop drawings.

They shall meet the following requirements:

- noise level shall not exceed 40 dBA when measured at a distance of 1 meter from the grille
- air velocity in the occupied zone shall not exceed 0.25 m/s.

Grilles and diffusers shall be installed by concealed hooks. Junctions between ducts shall be as shown on the drawings.

Wall mounted grilles shall be fitted with a wooden frame to be secured before rendering works.

Grilles shall have manually adjustable sheet steel fins, 1 mm thick, easily accessible from the exterior.

309.5.5 External air louver (EAL)

Extract and fresh air external louvers shall include:

– A frame made of angle iron to be fixed to the wall
– A frame with rainproof fixed fins and bird screen grille.

Louvers shall meet the following requirements:

– Velocity of air : 500 FPM maximum
– Head loss : 5 mm water column maximum

309.5.6 Bird screens and frames

Bird screens shall be installed on all fresh air inlet louvers and shall conform to FS RR-W-360, Type I, Class 1, 2 by 2 mesh, 0.063 inch diameter aluminum wire or 0.031 inch diameter stainless steel wire. Frames shall be removable type or stainless steel or extruded aluminum.

309.5.7 Air filters

Filters shall be provided for fresh air and for mixed fresh and return air.

For both the applications, the filters shall be 50 mm thick permanent metallic washable type. Filter media thickness shall be not less than 45 mm. (Synthetic or natural washable filter media may be used with prior approval. Self cleaning inertia type fresh air filters may be necessary for large installations.

Filters are normally placed upstream of the main supply fan and the cooling coil. Apart from producing clean room air, this protects cooling coils and other apparatus from deposition of dust. The system shall be arranged to provide an even velocity distribution across the filter face.

Where extra clean contamination free air is required, high efficiency filters, normally used in conjunction with prefilters, are placed down stream of the fan and shall be the last item of equipment before the discharge point. This ensures that any air leakage is outward and that contaminated air is not drawn into the system, also that any contamination from air handling equipment (e.g. carry-over of dust particles from humidifiers) is captured by the final fiter. Prefilter construction shall be as described above.

309.5.8 Fresh air intakes (FAI)

Fresh air intakes shall be as remote as possible from concentration of surface or roof dirt and positioned to avoid intake of fumes or odours. Inlet grille or wire mesh bird/insect screen and volume control damper shall be fitted ahead of fresh air filters. In some cases the fresh air intake may need acoustic treatment to reduce noise from or into the system. Air inlets shall be positioned at least 1.2 m above ground level. Goose neck connections shall be provided to prevent ingress of rain water. sand traps may be required in areas which experience high incidence of dust.

Adequate access to facilitate servicing of the filters shall be provided and access doors, ladders, electric lighting included where necessary.

All ducts shall be clean and free from builder's rubble and dust before filters are installed. The correct flow direction shall be observed. The frame holding the filter media, when in position, shall form an effective seal so that no air bypasses the filter.

309.6 THERMAL INSULATION

309.6.1 General

Insulation shall be carried out neatly and to 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 galvanized surfaces.

All duct flanges, stiffeners and inspection doors etc. should be insulated in accordance with the recommended practices and to the Engineer's approval. Strainers, valves (size 80 mm and above) and other fittings which require opening for maintenance/repairs shall be provided with insulated boxes. Inspection door insulation thickness shall match the surrounding ducts.

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

All duct and 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 carefully 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.

309.6.2 Rectangular ductwork insulation

All rectangular supply and return duct work shall be insulated with rigid fiberglass slab covered with reinforced aluminium foil. The slabs shall be free from shot or coarse and have density of not less than 48 kg/m^3 and thermal conductivity not more than .037 w/m °C. The slabs shall be fixed applying approved adhesive material of high quality to entire surface of both the duct-work and insulation slabs and fixed in place immediately. (The adhesive shall be applied to both the edges of the slab also). All joints shall be sealed using 75 mm wide self adhesive tape. Minimum time should be permitted to lapse between applying self adhesive tape and applying vapour barrier to insulated surfaces.

All duct work external to the building shall be insulated with 50 mm thick fiberglass slab and covered with fiberglass cloth of 200 gm/sq.m quality.

All duct work within the building, except plant rooms, shall be insulated with 25 mm thick fiberglass slab and covered with high quality canvas of 200 gm/sq.m quality.

Fresh air and exhaust air ducts shall be suitably insulated wherever possibility of external or internal condensation exists.

Hardwood battens shall be provided between the ducts and the supports. Wood shall be treated for protection from fungus and termite.

Plastic insulation hangers shall be provided as additional support to the insulation of rectangular ducts with a side dimension in excess of 600 mm. Hangers shall be fixed to the bottom and sides of the ducts using blind rivets spaced 300-400 mm apart.

309.6.3 Circular ductwork insulation

Circular supply and return air ductwork shall be insulated with flexible fiberglass blanked of density 24 Kg/m^3 covered with reinforced aluminium foil. Blanket thickness shall be 50 mm compressed to 25 mm during application for internal ducts and 100 mm compressed to 50 mm for external ducts. Method of application of insulation shall be same as for rectangular ducts. In addition, 25 mm wide aluminium bands shall be provided at 500 mm centers.

Sectional treated hardwood rings or approved plastic inserts shall be provided between the ducts and the supports.

Vapour sealing over the insulation shall be carried out in the same manner as for the rectangular ducts. Additional protection shall be provided for exposed insulated circular ducts, if specified.

Preinsulated flexible ducts shall be subject to the approval of MEW. Insulation density shall be not less than 16 Kg/m^3. Insulated flexible duct connections to grille/diffuser plenums shall be covered with canvas and vapour sealed as per the rest of the air ducts.

309.6.4 Drain pipe insulation

All condensate drain pipes within plant room or other internal areas subject to damage or sweating shall be insulated using 25 mm thick glassfibre or 10 mm foam rubber insulation applied and vapour sealed as for duct insulation.

309.6.5 Refrigerant pipe insulation

Refrigerant suction lines shall be insulated using 19 mm thick foam rubber or 50 mm thick rigid fiberglass and vapour sealed in the same manner as duct insulation. Refrigerant suction lines of small split air conditioners (upto 2.5 Ton nominal capacity) may be insulated using 10 mm foam rubber and vapour sealed. Refrigerant suction lines within packaged equipment shall be insulated with at least 19 mm rubber foam with protective paint. Metal cladding over insulation may be specified for large evaporator shells.

309.7 SOUND AND VIBRATION CONTROL EQUIPMENT

309.7.1 General

Care shall be taken in the selection and location of mechanical and electrical equipment to ensure that the noise or vibration that it produces does not cause annoyance to occupants within the building where it is located or to people in surrounding areas (either indoors or outdoors). Particularly careful consideration shall be given to the sitting of outdoor equipment, including cooling towers, if required, air cooled condensers, remote condensing units, externally mounted fans. Specialist advice is essential when large machines are to be mounted on roof or intermediate floors.

Proper consideration shall be given to the sitting of supply and exhaust louvers on the building exterior to prevent problems owing to unwanted sound passing outward (or inwards) through these openings.

309.7.2 Sound attenuators

Sound attenuators and lining materials in duct work systems, and anti-vibration devices for equipment, shall be located strictly in accordance with design requirements and manufacturer’s recommendations.

Installation of specially designed sound attenuators shall be preferred over duct lining.

The material employed for sound absorption within attenuators, mixing boxes and room terminals and ductwork lining are generally susceptible to physical damage and to severe deterioration if exposed to rain or water. It is essential that adequate protection is provided not only during storage and installation, but at all times upto system handover.

309.7.3 Antivibration devices

Anti-vibration devices include compression materials and rubber in sheer isolators. These materials may be damaged physically, or by liquid such as oil, and adequate precautions are therefore essential.

Packaged units, installed at ground level, indoor free standing units and air handling units shall be mounted on anti-vibration units in the form of multilayer rubber pads. Equipments installed on the roof may be mounted on rubber pads or springs suitably selected and approved by the manufacturer.

Multi layer pads shall be composed of rubber sheets, preferably with square grid pattern on both sides, and steel sheet inserts of 16 gauge. The composite pad thickness shall be selected to suit the equipment, but shall be not less than 32 mm.

AV pads for small packaged units, air handling units, condensing units, fans, etc. shall contain counterbored holes and fitted with suitable rubber grommets to permit free passage of foundation bolts without making contact with the equipment.

Spring type vibration isolators shall be fitted with limit stop to prevent excessive movement and there shall be a compensating pre-setting.

Care shall be taken to prevent any anti-vibration devices being loaded beyond their safe limits during erection of machinery.

309.7.4 Flexible duct

Flexible duct joints shall be provided at inlet and outlet of each fan, air handling unit and packaged unit. The joint material shall be flame retardant.

309.7.5 Others

Flexible electrical conduits shall be provided for final connection to chillers, pumps, air handling units, fans and any other vibrating equipment.

Care shall be exercised to ensure that antivibration mounts are not “bridged-out” by direct contact between the equipment and building structure through foundation bolts, hangers, rigid pipe or cable connections, rigid clamping of equipment body to any element of the building or through bottomed mounting springs. All shipping bolts and stoppers must be removed before commissioning.

309.8 INSTRUMENTATIONS

309.8.1 Test points for air distribution system

Adequate test hole fittings shall be provided in the air ducts to facilitate accurate measurement of air flow using pilot tube traverses. Test hole fitting shall have at least 25 mm dia bore

complete with an effective removable seal. Location of test points should be clearly marked on the insulation surface.

Test points shall be provided at the following locations :
- At all fans 9in the straightest section of duct near to the outlet).
- At main branches.
- After regulating dampers.
- After cooling coil and heating batteries.
- At any other position indicated on the drawings or necessary for balancing the air system.

309.8.2 Manometers

U-tube type manometers shall be installed to measure the pressure drop across filters. The manometer shall have coloured fluid for easy readability and the tube shall be protected by a metal or plastic casing.

Manometer shall be installed at the following locations :

- Across fresh air filters of large air handling units.
- Across fresh air filters of air handling units for 100% fresh air applications.
- Across mixed fresh and return air filters of air handling units and packaged units for normal air conditioning.
- Across all high efficiency filters.

Inclined tube manometers may be used for special applications.

309.8.3 Smoke detectors

A smoke detectors suitable for duct mounting shall be installed in the main returns air duct adjacent to each packaged unit. The smoke-detector shall be photoelectric obscuration type and shall be interlocked with the motor to stop it in the event of smoke detection. It should operate on 240 volts with two volt free contacts and shall be manual reset type.

309.9 CLEANING AND ADJUSTING

Equipment shall be wiped clean, with traces of oil, dust, dirt, or paint spots removed. Temporary filters shall be provided prior to startup of all fans that are operated during construction, and new filters shall be installed after all construction dirt has been removed from the building. System shall be maintained in this clean condition until final acceptance. Bearings shall be properly shall be properly lubricated with oil or grease as recommended by the manufacturer.
Belts shall be tightened to proper tension. Fans shall be adjusted to the speed indicated by the manufacturer to meet specified conditions.

310. GAS CHLORINATION

310.1 GENERAL

Gas chlorination equipment for installation at pumping stations, reservoirs and water treatment works and other locations on the system generally come under one of two categories.

a) Gas chlorination feeding into pressurised and gravity lines at locations where an electricity supply is available.

b) Gas chlorination at those locations, such as water catchment works, outlets from reservoirs etc where there is no electricity supply.

This specification cover both categories.

The Contractor is responsible for the safe design, provision and installation of the chlorination dosing system and associated safety equipment. The safety equipment required varies from site to site depending on site location, quantity of chlorine stored or dosed and type of equipment supplied. The contractor shall access the requirements of each installation with respects to the following points:

– ventilation system
– leakage detectors
– audio and/or visual alarms
– automatic shut down systems
– personal protection equipment
– procedures and training.

The equipment called for in this section are nominal requirements, and shall be supplemented with required system per manufactures recommendation for safety and operation.

310.2 SCOPE OF WORKS

The scope of works for the provision of chlorination equipment includes, as appropriate to the particular category above:

1. Supply and transport to site of all equipment including chlorinators, centrifugal booster pumps, chlorine bottles, and all other material and equipment necessary for the installation.
2. Installation of chlorination equipment and fittings, pumping equipment, metering, pipework and valves, control and protection equipment to form an effective and fully operational installation.
3. All necessary civil and building works.
4. Testing commissioning and putting into service all equipment.

310.3 VACUUM CHLORINATION OF PRESSURISED WATER SYSTEM

This system is applicable at pumping stations, water catchment works etc where the water to be treated is under pressure and electricity is available.

A centrifugal booster pump shall be provided to supply pressurised water to the chlorinators.

Where specified the rate of chlorine injection shall be controlled by flow metering and valving as a function of the water flow rate.

Equipment Characteristics

Injection of chlorinated solution shall be by vacuum type chlorinator, the vacuum being achieved by pressurised water and injector.

The chlorinator may be either wall mounted or mounted directly on the head of the chlorine bottle. It shall include:

- Pressure reducing valve
- Flow control valve
- Injection device
- Pressure relief valve to act in case of surge pressure of chlorine or loss of suction.
- Pressure gauges up and downstream of the booster pump.
- Non return valve downstream of the chlorinator.

The injection service pressure (bar) and chlorinator capacity shall be calculated by the Contractor and designed from information in the particular specification for each installation.

The Contractor shall supply all necessary equipment and fittings for operation, control and maintenance in accordance with the following list.

The list is indicative and by no means restrictive.

Water Circuit

a) Motor Driven Pumpset
An electric motor driven pumpset shall be provided to achieve the discharge rate and pressure for chlorinator operation.
The booster pump discharge rate and pressure shall be as the chlorination equipment manufacturers specification. The pump assembly shall comprise a three phase 380V electric motor with a minimum protection class IP55 and maximum speed of 3000 rpm., and a centrifugal pump mounted on a common base plate.

b) Non return valve downstream of the pump.

c) PVC or bronze valves (Upstream and downstream of the pump)

d) PVC or bronze control valve downstream of the pump.

e) Bronze strainer (1mm) upstream and downstream of the pump.

f) 10 or 25 bar pressure gauges as appropriate upstream and downstream of the pump.

g) Piping, treated against or resistant to corrosion.

Chlorine Circuits

a) Chlorine resistant non-return valve.

b) Anti-siphon system

c) Chlorine resistant chlorinated solution injection device.

d) Chlorine resistant pipework for chlorinated solution injection.

e) Chlorine resistant pressure relief piping for release of gaseous chlorine in the event of over pressure, to a maximum length of 8m.

f) Piping between chlorinator and injection device, complete with fittings, all of chlorine resistant material.

310.4 CHLORINATION OF PRESSURISED AND GRAVITY SYSTEMS IN THE ABSENCE OF ELECTRIC POWER SUPPLY

This system is for use where there is no power supply available, for example supply and delivery lines at reservoirs, catchment areas and headworks.

The chlorination process shall cease immediately in the event of lack of water.

a) Chlorination under low pressure

Use of low pressure chlorinators shall only be used where use of vacuum types is impossible due to insufficient line pressure.

The chlorinator shall be either wall mounted or directly assembled to a gaseous chlorine bottle, the latter providing pressure for operation of the chlorinator. A chlorine resistant piping connection shall link the chlorinator to a diffuser. In the case of a reservoir a spring loaded check valve shall be installed at the point of chlorine injection.

A nozzle injector rather than a diffuser shall be used for injection into a pipeline.

Where injection is into the pipeline pressure in the line shall always be more than 0.1 bar (g) and shall not exceed 0.7 bar (g). Partial vacuum in the pipe must be prevented.

In the case of a reservoir the level of water in the reservoir shall always be at least 1m above the diffuser.

The size of the piping between the chlorinator and the injection point will be a function of both dose rate and distance between the points.

b) Chlorination by Vacuum Chlorinator

Chlorination under vacuum only applies to reservoir gravity supply lines, the latter associated with a minimum hydraulic pressure of 0.5 bar. A hydro ejector shall achieve the required hydraulic pressure for injection provided a pressure drop is produced downstream of the hydro ejector feed point (By a valve or diaphragm).

The Contractor shall optimise the locations of feed and injection points in such a way as to achieve a minimum hydraulic pressure of 0.5 bar upstream of the hydro ejector. The capacity of the chlorinator shall not exceed 200 gr/hr at a hydraulic pressure of 0.5 bar or 300 gr/hr at a pressure of 1 bar, unless otherwise specified.

Chlorination shall cease immediately in the event of lack of water in the line.

c) Chlorination Dosing Pump

Disinfection shall be achieved by injection of chlorinated lime or sodium chloride (Javel water), by means of a dosing pump proportionally to the rate of flow of water. The chlorinated solution shall be stored in corrosion proof tanks.

The operation of the dosing pump shall be controlled by a flow meter equipped with a pulse transmitter. A control system receiving the transmitted pulses, shall regulate the dosage of chlorinated solution.

Supply of power shall be by:

A low leakage, self discharge, maintenance free battery with no water addition required.

A battery charging solar panel complete with either a charge regulator or an electronically controlled battery charger housed in a class IP55 box equipped with LED indicator. The contractor shall supply and install such other equipment as may be necessary for the operation of the system.

310.5 CONTROL SYSTEMS BASED ON FLOW RATE OF WATER

310.5.1 General

The control system shall comprise a chlorine injection regulating system. It shall include:

a) A chlorinator for use with pressurised water systems.

b) A water flow meter with an output signal proportional to the rate of flow to be treated.

c) A motorised chlorine flow control valve with feedback signal to the control system, the signal to be proportioned to the chlorine injection rate.

d) A feed back control system with signal comparator. In the case of signal discrepancy the control valve servomotor shall be actuated to adjust the injected dose of chlorine.

e) The injection nozzle and/or hydro ejector.

f) If specified the facility to receive a signal from a residual chlorine analyser which will adjust the chlorine/water ratio.

310.5.2 Requirements of the above Control Systems

a) Chlorine Flow Control Valve

The motorised control valve shall be functionally compatible with the chlorinator. It shall achieve automatic control of the chlorination process as a function of the rate of flow of water to be treated.

The supply voltage shall be 220V, 50 Hz with a two pole circuit breaker equipped with adjustable thermal trip.

The valve capacity shall not exceed 10 kgf (gaseous chlorine)/hr. It shall receive and transmit a 4-20 mA signal to the chlorinator. The valve can either be incorporated in the chlorinator or installed separately in the system.

b) Water Meter

The water flow meter which may be of the turbine, magnetic flow, diaphragm or ultrasonic type, shall control the operation of the motorised control valve. It shall have the following characteristics.

a) Be suitable for fluids with up to 80 mg/l solids particle content. It shall be designed for a range of water velocities from 0.5 to 3.0 m/s and shall transmit a 4-20 mA signal.
b) Operate on a supply voltage of 220V or 110V - 50 Hz.
c) Be equipped with a rate of flow indicator.

310.6 CONTROL SYSTEMS BASED ON RESIDUAL CHLORINE METERING

310.6.1 General

The system shall include:

a) A vacuum chlorinator injecting into a pressurised water system.
b) Chlorine injector flow control valve actuated by a converter to a residual chlorine analyser with signal transmission to the control valve of a signal proportional to residual chlorine concentration in the treated water.
   The residual chlorine analyser shall be equipped with an electronic transmitter, and shall be one of two types.

310.6.2 Type “A” (with reagent)

The residual chlorine analyser shall be of the amperometric type for measurement of residual chlorine in water.

It shall include:

1. Measuring cell.

2. Suitable reagent to allow measurement of the concentration of total and/or free residual chlorine.
3. Amplifying circuit and converter with 4-20 mA output signal. The above to be incorporated in the analyser bar.
4. Zero point and scale adjustment features with automatic temperature compensation feature, to compensate for errors due to temperature fluctuation of the sample.
5. Direct reading indicator.
6. All components to be installed in a corrosion resistant box. The characteristics shall include:

    - Scale range 0-0.5, 0-2.0 mg/l
    - Water sample temperature range 0-50^{o}C.
    - Output signal 4-20 mA
    - Supply voltage 220v - 50 Hz with 2 pole circuit breaker with adjustable thermal trip.
    - Indicator: located on front of analyser.
      Direct reading in mg/l
      Accuracy ±2% of scale range.

310.6.3 Type "B" (Dry Type)

The analyser shall consist of a potentiometric cell fitted with three metallic electrodes that shall generate a current directly proportional to the concentration of free residual chlorine.

It shall be equipped with a potentiometric amplifier and a converter to transform the current to a 4-20 mA signal.

The circuitry shall include a zero point and scale adjustment feature as well as automatic temperature compensation feature (Thermistor) in order to compensate for errors due to temperature fluctuations of the sample.

It shall have a direct reading indicator and be installed in a corrosion resistant box.

- The characteristics shall include:
- Scale ranges 0-0.5, 0-2 mg/l
- Water sample temperature range 0-50^{o}C
- Output signal 4-20 mA
- Supply voltage: 220V - 50 Hz with 2 pole thermal magnetic circuit breaker.
- Indicator: located on front of analyser
  Direct reading in mg/l
  Accuracy ±2% of scale range.

310.7 AUXILIARY EQUIPMENT FOR CHLORINATION AND STORAGE

310.7.1 General

Where electric power is available the chlorination room shall be equipped with an extractor fan roof mounted cowl typetop discharge (10m static pressure), suitable for chlore extraction. The fan shall be connected to a PVC pipe of 100mm bracketed off the internal wall of the rroms. The pipe shall run vertically inside the rooms and be fitted with a mosquito net and weather cowl at the inlet. The fan shall give twenty air changes per hour and shall have a

control switch located outside the building. A sign shall be fixed outside on the door “Danger, Toxic Gas - Access for authorised personnel only”.

These shall be available at each chlorination building 2 No gas masks consisting of an integral mouth piece and wide view visual piece covering the entire face, complete with flexible breathing tube and filter cartridge with hipstraps.

2 No additional filter cartridges shall be supplied with each mask. The masks shall be kept in a dedicated wall mounted cupboard in the control room or attendants room. The cupboard door shall have affixed to it a label stating “Chlorine gas masks. Fit new cartridge before use "قناع واقٍ من غاز الكلور - بدل القارورة قبل الاستعمال" , in both Arabic and English.

The filter shall be effective in neutralising gaseous chlorine.

A emergency eye wash and shower system shall be fitted to the wall immediately outside the chlorination room for emergency use. It shall have a chain operated valve.

When specifically called or deemed necessary, the chlorination room shall be fitted with an orange windsock of airport quality mounted on the top of the building. The sock shall be made of nylon and shall be chemically treated and ultraviolet dyed to prevent fading. The sock shall be mounted on a frame specially made for this application that does not lock up and shall be visible from the entrance door of the chlorine building.

310.7.2 Chlorine Bottles

2 No chlorine bottles shall be supplied with each chlorinator. They shall be 50 kgf capacity each unless specified otherwise.

Each bottle shall be equipped with:

- An isolating valve, which shall be provided with a protective cap during transport.
- Where specifically called for, an automatic chlorine supply change over to a standby bottle on depletion of the duty bottle. The system shall be wall mounted and shall be functionally compatible with the chlorinators. It shall function on partial vacuum and shall be complete with all accessories and fittings The change over switch should include an indicator showing the cylinder in service.
- A bottle rack and chain support.
- Where specifically called for, a permanent weighing device shall be provided beneath the bottle in service to continuously monitor the rate of chlorine consumption.

310.7.3 Chlorine Detector

Where specifically called for or deemed necessary, gaseous chlorine detector units shall be fitted. The gas leak detector shall be used in conjunction with an alarm which shall be actuated if the gas concentration arises above 1 ppm or 3 mg gas/cu.m of air.

The detector may be one of two types:

310.7.3.1 Type A (Dry Cell)

The gas detector shall consist of an independent tank and detection cell located outside the tank. The tank capacity shall be sufficient to give 6 months operation. The detection cell (sensibility 1mg/cu.m) shall be connected to an electronic measuring device located in a wall mounted box. In the presence of an oxidising gas the detection cell shall generate a current proportional to the gas concentration.

The box shall have an electronic indicating device and shall give continuous monitoring.

When gas concentration reaches its maximum permissible limit the detector shall activate visual and acoustic alarms, and shall trigger the operation of a remote alarm, where fitted, the operation of the extractor fan and closure of the supply line valves.

A test push button shall be provided to allow the operation to be checked.

310.7.3.2 Type B (Wet Cell)

The detector shall have live electrodes under constant supply voltage, immersed in an electrolyte that shall conduct current in the presence of an oxidising gas. The generated current shall be amplified and converted to a signal.

310.8 LEAK DETECTION, RESIDUAL, FREE RESIDUAL AND TOTAL RESIDUAL MEASUREMENT

A bottle of liquid ammonia for chlorine vapour leak detection purposes and a measuring kit for quick determination of the concentration of the following shall be provided with every chlorination equipment installation.

- Free residual chlorine
- Residual chlorine
- Total residual chlorine

Details of the equipment to be provided, which shall include all auxiliaries, shall be provided with the tender.

310.9 MONITORING AND CONTROL

The chlorination system shall have interface signals for the monitoring and/or control by a central computer station as specified.

As a minimum requirement, the chlorination system shall acquire the flow measurement analogue signal and provide the following outputs:

– RS 485 interface output for data exchange with computer based systems (PLCs, Monitoring station, etc.)
– Residual chlorine analogue signal where specified.
– Booster pumps status (ON/OFF/FAULT).
– Chlorine leak detection alarm.

– Vacuum switch alarm. This switch shall be integrated or fitted to the chlorometer to signal high or low vacuum level to the plant control system. The alarm shall be visual and audible. The switch contacts shall be set at manufacture as required by the particular site at which the chlorinator is to be installed.

310.10 INSTALLATION OF EQUIPMENT

The location of the chlorine bottles in the store shall be away from direct sunlight at all times. During transportation of bottles the contractor shall ensure that gas bottles are not overturned and that safe handling procedures are adopted at all times.

Gaseous chlorine piping connections between system components shall follow the shortest and most direct route possible and shall be laid to falls.

Water and other piping shall not be laid immediately alongside gaseous chlorine piping in order to prevent cooling and condensation.

Only grease or other lubricant as recommended by the equipment manufacturer shall be applied to all removable fittings.

Where the chlorinator is installed remote from the gas bottle the distance apart shall not exceed 10 metres.

The chlorinator vapour vent pipe shall be extended to outside the building away from inhabitated areas. The vent pipe outlet shall be covered with a mosquito net.

Chlorination equipment piping shall be secured to the wall by brackets with a minimum clearance of 100mm off the walls for painting and maintenance purposes.

310.11 SYSTEM START-UP

The procedure for putting chlorination equipment into service shall include:

- A bacteriological and physico-chemical analysis of the water to be disinfected.
- Determination of the chlorine demand of the water to be disinfected based on break point method.
- Adjustment of the chlorinator capacity to achieve, after 30 mins of chlorine to water contact a residual concentration of 0.5 mg/l. A check shall be made by measurement of the concentration of free chlorine in water at a pre-determined location in the water distribution system.

In the case of a chlorinator controlled by an automatic residual chlorine measuring device, the indicated concentration shall be checked against the result of an analysis of residual chlorine in the water sample.

310.12 DISINFECTION CONTROL

Following start up of the chlorination system the contractor shall take five samples of disinfected water at five different locations situated at representative distances from the chlorination point so as to achieve effective control of the quality of disinfected water. The following tests shall be undertaken.

- Measurement of free chlorine (Type b1)
- Measurement of free chlorine in water.

310.13 SITE PROCEDURES AND TRAINING

310.13.1 General

Training should be carried out with emphasis being given to safety precautions and methods of dealing with emergencies. Particular attention should be given to the following aspects:

(a) the hazards and characteristics of the material;
(b) safe methods of plant operation, including handling of the connection to supply systems;
(c) methods of maintenance;
(d) special operations; for example, plant shut down and start-up, methods of isolation and preparation of equipment for periodic maintenance and inspection;
(e) the location and operation of emergency shut-off valves;
(f) the procedures to be followed if releases occur;
(g) training in the use of all personal protective equipment supplied.

310.13.2 Operating Instructions

The operating instructions should cover each process operation. Written operating instructions are required, in English and Arabic, for all routine and emergency operations, ranging from guide cards for simple operations to complete manuals.

Copies of the instructions, which should include a flowsheet and indicate valves to be closed in an emergency, should be available in the working area for operators.

310.13.3 Emergency Arrangements

The emergency procedure should include how gas releases may be dealt with safely by site personnel. The procedure should cover various degrees of emergency and should be either supplied in written form or made available to employees so that they know the steps they are required to take. This procedure should include first aid and evacuation arrangements.

310.14 TESTS ON COMPLETION

The tests on completion of the chlorination system shall include the following:

1. Injection rate
2. Injection pressure
3. Absence of leaks
4. Injected concentrations
5. Compliance with specification
6. Safety criteria
7. Such other tests as the Engineer may determine.

310.15 NEUTRALIZATION CHAMBERS

Where specifically called or deemed necessary, a neutralization chamber shall be provided. For safety considerations a chlorine leak detection and neutralization system shall be provided with a capacity to treat the chlorine fumes of the largest full chlorine container present at the site. The neutralization system shall have adequate absorption stages operating under negative pressure (vaccum) including all ducting. It shall consist of the following:

1. A fan to extract the chlorine-laden air;
2. A neutralization tower with contact rings, mist eliminator, and vent system;
3. Necessary neutralization and water recirculating pumps, nozzles, sprayers, piping, valving, etc...
4. A storage tank for the neutralization solution and required chemicals;
5. Necessary ducting, piping, valves, fans, and miscellaneous appatenances;
6. Electric and Mechanical auxiliaries for monitoring instrumentation and control.

The neutralization system shall be capable of treating chlorine gas release at a rate of 45Kg/min with an overall efficiency performance of 99.998 percent removal of the chlorine vapor in the vent discharge.

The scrubber system shall run until the gas concentration in the chlorine storage room is reduced to 1 ppm in less than an hour.

The leak detector and the extractor fan inlets shall be positioned at floor level in the storage premises. The chlorine storage units, the evaporator-chlorinator assembly, and the leak neutralization tower shall be located in separate rooms. In the event of a chlorine leak in the premises where the chlorine cylinders are located, a chlorine leak detector shall sound an alarm lock up the ventilation fans and automatically start the fan that extracts the air from the polluted places to the neutralization tower. The chlorine laden-air flows shall go through the mass of contact rings in the opposite direction to the neutralizing solution. The chlorine neutralization system shall be capable of neutralizing the volume of the largest full chlorine container present at the site.

PART 6

TESTING AND COMMISSIONING OF MECHANICAL AND ELECTRICAL EQUIPMENT

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601. GENERAL REQUIREMENTS

"In factory tests" shall be carried out if requested in the Particular Specifications.

"Commissioning tests" (tests on completion) shall be carried out at the end of the works following pre-commissioning.

"Performance tests" shall take place during the defects liability period. Test shall be consistant with the specifications of the contract document and the standards in force.

Analytical instruments for testing shall be sealed and supplied with recent calibration certificates provided by an official laboratory.

The results of tests shall be set out in a report signed by the Engineer or his representative and by the Contractor.

601.1 ABBREVIATIONS

The following abbreviations are used in these documents :

1/head/day	liters per head per day
AC	Asbestos Cement
AGMA	American Gear Manufacturer's Association
AOD	Above ordnance datum
BS	British Standard
CDR	Council for Development and Reconstruction.
CFM	cubic feet per minute
Ch	Chainage
CMR	Continuos Maximum Rating
CP	Code of Practice
CPU	Central Processing Unit
DI	Ductile Iron
DIN	Deutsch Industrie Normen
DOV	Double Orifice Valve
DPSK	Differential Phase Shift Keying
DTU	Documents Techniques Unifiés
EDL	Electricity of Lebanon
EMC	Electromagnetic Compatibility
EOH	End of hole.
FDS	Functional Design Specification
FIDIC	Federation Internationale des Ingénieurs- Conseils
FSK	Frequency Shift Keying
g	acceleration due to gravity ($9.807 m/s^2$)
GL	Ground level
gpm	gallons per minute
gr	gram
GRP	Glass Reinforced Plastic
GTSD	General Technical Specification Document
hr	hour
I/O	Input / Output
IEE	Institute of Electrical Engineer

ISO	International Standards Organization
ITS	Institute of Technical Studies
kgf	kilogram force
kPa	kilo Pascal
kVA	kilovolt-ampere
kW	kilowatts
kWh	kilowatt hour
LED	Light Emanating Diode
m	meters
m/s^2	meters per second per second
m^3	cubic meters
m^3/day	cubic meters per day
MDPE	Medium Density Polyethylene
mgd	million gallons per day
mhd	meters head
mm	millimeters
NFE	Normes Françaises - (Electrical)
NLQ	Near Letter Quality
NPSH	Net Positive Suction Head
PS	Particular Specification
PTT	Poste de Téléphone et de Télégraphe
PVC	Polyvinyl Chloride
PWL	Pumping Water Level
RAM	Random Access Memory
RBC	Rotating Biological Contractor
RTR	Reinforced Thermoplastic Resin
RTU	Remote Terminal Unit
SCADA	System Control And Data Acquisition
SOV	Single Orifice Valve
SPTD	Signal Pole Double Throw
SSU	System Supervisory Unit
SWL	Static Water Level
TDH	Total Dynamic Head
TDM	Time Division Multiplex
TEFC	Totally Enclosed Fan Cooled
UHF	Ultra High Frequency
UPS	Uninterrupted Power Supply
UPVE	Unsaturated Polyvinyl Chloride
VDU	Video Display Unit
VGA	Video Graphics Array
VHF	Very High Frequency
VHS	Video Home System

602. IN FACTORY TESTS OF PUMPSETS

602.1 GENERAL

Pump testings shall be determined according to the pump tests carried out by an international control organisation, i.e. EUROPUMP, the committee of European manufacturers of pumps which divide them into two classes :

- Class A : special pumps
- Class B : small pumps manufactured in large quantities.

Class A

The Engineer or his representative shall determine, in the description of the project, whether the pump(s) or its (their) motor(s) shall be tested in factory.

The Contractor shall submit the original estimate of the manufacturer, justifying the costs of the required in factory tests. The price shall be detailed according to the requirements of the Engineer.

Class B

Equipment manufactured in large quantities shall not undergo in-factory tests.

The manufacturer shall produce, for the manufacture criteria and their justifications, the characteristic curves of each pump ordered by the Contractor :

- Flow curve
- Efficiency curve
- Power curve
- Suction curve (NPSH)

The complete control of operation conditions shall be carried out as soon as the equipment is installed on site.

Where pumps operate in series or in parallel, the Contractor shall justify the operation characteristics by producing analogous curves specifying the starting and releasing points for an automatic or manual operation.

602.2 PUMPSET TESTS

Verifications and tests shall be carried out in factory, in conformity with the international tests standards in force in the country of origin or with those equivalents to international standards adopted for the manufacture of the equipment before transporting the equipment.

These tests shall be carried out at the expense of the Contractor, and under the supervision of an international control organisation, i.e. EUROPUMP.

The international control organisation shall be considered as “The In-Factory Taking Over Agent”. Nevertheless, in factory taking over shall not supersede the on-site “Taking Over Of Works”.

These tests shall allow a complete control of all the guarantees stipulated in the tender document, as well as the verification of the equipment consistency with the adopted manufacture standards. They shall also provide the information mentioned hereinafter.

In particular, these tests shall be carried out at the maximum nominal speed and in conformity with the adopted standards.
However, no tolerances shall be permissible in any way regarding the guarantees of flows, lift heights, and efficiency.

Tests shall include, particularly:

For the pump:

- The determination of the lift head of water at the specified flow rate set out in the tender document.

- The determination of the flow at the TDH.

- The drawing of characteristic curves (efficiency, NPSH, required power, “head - flow” curve).

- The determination of the pump efficiency at the specified flow.

- The determination of the pressure when the discharge outlet is closed while pump is running.

- The hydrostatic test.

- The determination of the inertia of revolving parts.

For the electric motor

- The determination of the nominal power.

- The determination of the nominal speed at the nominal power.

- The determination of the nominal current under working voltage.

- The determination of the starting current in case of direct starting.

- The determination of output shaft torques (nominal, starting, breakdown) and the drawing of the characteristic “torque-speed” curve.

- The determination of the efficiency at the duty point.

- The determination of the efficiency at 2/4, 3/4, and 4/4 of the load.

- The determination of power factors at 2/4, 3/4 and 4/4 of the load.
- The determination of the inertia of revolving parts.

– Heating tests

– Dielectric tests

– Overspeed tests

– Measurement of the noise level.

Prior to the installation of equipment, the Contractor shall submit to the Engineer in triplicate the tests and "in factory taking over" certificates, duly certified by the International Control Organisation, attesting that the tests carried out on the equipment meet the conditions of the Contract and that the equipment is in conformity with the specifications of the tender document.

602.3 "IN FACTORY TESTS" PENALTIES

Unless otherwise specified, if the values of efficiencies and flow rates recorded during the "Factory Test" are not in conformity with the declared values, penalties shall be calculated as follows:

– Declared Overall Efficiency = (Declared Efficiency$_{Mtr}$ X Declared Efficiency$_{Pump}$) at the TDH.
– Declared Fow Rate = Flow rate at the TDH.

- 2% of the value of the equipment for each 1% of overall efficiency inferior to the declared values.
- 1% of the price of the equipment for each 1% flow rate inferior to the declared flow rate.
- 0.5% for each 1% flow rate superior to the declared flow rate.

The maximum total penalties on efficiency and flow rates shall be fixed at 5% of the motopumpset value, beyond this rate the motopumpset shall be rejected.

When the power required by the pump is not compatible with the motor provided, the motopumpset shall also be rejected.

603. TESTING ELECTRICAL PANELS IN WORKSHOPS

Tests of each electrical panel must include at least the following verifications:

- Verification of the aspect, accessibility of mechanical equipment, as well as strength and operation of mobile elements, precautions taken to prevent corrosion and protect paint, wires and cable runs, and marking operations, etc...
- Verification of the good functioning of mechanical and electrical control devices as well as efficiency of locking mechanisms.
- Verification of the electrical insulation.
- Verification of the continuation of sheathings.
- Verification of Earthing connections.

Moreover, all electrical equipment constituting the panels should have undergone in-factory tests determined by the relevant standards: IEC 439, etc...

604. TESTING OF VALVES

All valves shall be tested in accordance with BS pressure and material test certificates shall be submitted to the Engineer for approval.

605. ON SITE TESTS

They are carried out on electromechanical plant, generating sets and control systems.

Tests shall comprise, but shall not be limited to, the following:

605.1 VISUAL INSPECTION

- Checking the state of the equipment and the quality of work.
- Checking levels and alignments.
- Verifying the effective characteristics of the equipment.

605.2 ACOUSTIC TESTING (NFS 31-010 AND BS 7445-3)

Regulations related to the noise caused by machinery, in order to protect the neighborhood and the environment, are stipulated by the legislation governing installations classified as noisy.

The surrounding noise level measured from outside the building must not exceed:

45 dB (A) during day time, throughout the week
40 dB (A) from 8:00 PM till 10:00 PM throughout the week and on Sundays
35 dB from 10:00 PM till 6:00 AM during the night

The noise level may be increased according to the surrounding and to the satisfaction of the Engineer or the Employer (increase in dB (A)).

- Suburban residential area with low road traffic + 5 dB (A).
- Urban residential area + 10 dB (A).
- Urban residential area with workshops and heavy road traffic + 15 dB (A).
- Commercial or industrial area + 20 dB (A).

The tests and controls shall be carried out in some particular cases, upon an explicit request stated in the description of the tender document.

605.3 TESTING OF ROTATING ELECTRIC EQUIPMENT

605.3.1 General

All rotating electric equipment shall undergo preliminary works before their operation such as:

- Verification of the inside of the machine: rotor, stator, and magnetic core gaps of windings, presence of foreign bodies, etc... Dust removing by vacuum or compressed air (maximal pressure 4 bars).
- Verification of the correct tightening of all bolts, nuts, screws.

- Verification of all electrical protection equipment and instrumentation connections.
- Performance of operation tests and verification of the protective devices.
- Verification of electric connections and rotation direction.
- Measurement of insulating resistance and determination of the dielectric absorption ratio as directed hereinafter.
- Elimination of any condensation or humidity on the winding or the terminal box, by heating or according to the instructions mentioned below.

Upon completion of these operations, the rotating electric equipment is ready for operation.

605.3.2 Measurement of Insulation Resistance

Before measuring the insulation resistance, separate all winding terminals of each phase.

Windings of phases : (U_1 - U_2 , V_1 -V_2 , W_1 - W_2)

- With windings (V_1 -V_2) and (W_1 - W_2) connected to the frame, measure the insulation resistance between the winding (U_1 - U_2) and the frame.

- With windings (U_1 - U_2) and (W_1 - W_2) connected to the frame, measure the insulation resistance between the winding (V_1 - V_2) and the frame.

- With windings (U_1 - U_2) and (V_1 - V_2) connected to the frame, measure the insulation resistance between the winding (W_1 - W_2) and the frame.

- Measurements shall be carried out as follows: every 10 seconds, during the first minute, then every minute for the following nine minutes. It is advisable to use a motorised Megger.

- Voltage measurement values are the following :

  250 volts dc for $U_N \leq 500$ V
  2500 volts dc for $U_N > 4500$ V

- Static electricity shall be discharged with care before and after each measurement.

- The following formula shall be applied :

$$Ri \geq K \frac{U_N}{D}$$

Ri : (M Ω)	:	insulation resistance
K	:	temperature adjustment factor
U_N (KV)	:	Operation voltage of the machine
D (m)	:	Stator diameter Value = 1 if $D \leq 1$ meter Value = D if $D > 1$ meter

The value of the factor K in terms of the temperature is given in the following table:

Winding temperature (°C)	K
20	45
35	16
45	8
55	4
75	1

605.3.3 Determination of the Dielectric Absorption Ratio

The ratio is determined by the insulation resistance measurements corresponding to the first minute (R_1) and the tenth minute (R_{10}), as follows:

$$a = \frac{R10}{R_1} \text{ with } a \geq 2$$

Where a < 2, windings shall be cleaned and dried.

605.3.4 Cleaning of Windings

– If foreign bodies deposits are located in nooks inaccessible to dusters, it is advisable to use dry compressed air (max. 4 bars)

– Vacuum cleaning is required to prevent deposits from filling holes, setting between loose windings or damaging insulators when using compressed air.

– A solvent shall be used where oil or grease is mixed with dust. The solvent shall derive from petroleum and be selected so as not to damage insulators. Upon completion of the cleaning operation windings should be completely dry.

– Water may be used to clean dirty motors due to mud or eventual floods. This operation requires the disassembling of the motor in order to clean correctly and dry out all the parts.

605.3.5 Drying Windings with Air Circulation

Uncap the winding. Install a hot air blower (electrical resistance fitted with a fan) opposite the winding. The temperature of the air close to the winding shall not exceed 70°C.

Drying shall only require few hours, depending on the relative humidity and the power of the electrical blower.

605.4 TESTING OF HANDLING EQUIPMENT

All lifting equipment shall be tested at the manufacturer's works and on site. Tests on site shall comprise a full load test, including, where applicable, deflection checks on beams. Where the contractor wishes to use lifting equipment forming part of the permanent works for installation purposes he shall have the equipment tested and be in possession of a valid test certificate before using the equipment. All equipment must be tested or retested within one month of handing over to the Employer. Test certificates shall be provided in triplicate. The contractor shall be responsible at his own cost for the provision of all weights, slings and other equipment required for testing.

605.5 TESTING OF PLUMBING & SANITARY SYSTEM

The whole of the plumbing and sanitary system is to be tested on completion to the satisfaction of the Engineer and any defects shall be made good at the Contractor's expense.
The contractor shall provide all the labour, instrumentation, materials, temporary blank-off fittings, tools, plant and equipment required to complete all tests and commissioning.
Pressure tests shall be completed before any pipes are cleaned and before any insulation or protective covering is applied.
When a section of pipe work is complete and ready for testing, it shall be plugged and then slowly and carefully charged with water, allowing air to escape and avoiding all shock or water hammer. The contractor shall make arrangements for all water used in tests to be properly drained away.
Pipe work which fails under test, due to pressure loss or visible leakage, shall be relieved of pressure and all fault joints or other defects rectified to the complete satisfaction of the Engineer.
The Engineer or his representative will witness every test and the Contractor shall liaise with the Engineer, regarding the timing of the tests. All tests shall be repeated, if necessary, until such time as the engineer is satisfied. Test certificates shall be completed by the Contractor following each test and shall be submitted to the Engineer. The certificates shall state the following:

1. Pass / Failure
2. Pipe work section / Service tested
3. Equipment / Items on section excluded from test.
4. Test pressure and duration
5. Witness signature

Following testing, all pipe work and tanks shall be thoroughly flushed out and cleaned with potable water, to the entire satisfaction of the Engineer. After cleaning has been completed, the domestic hot and cold water lines shall be sterilised as follows:

1. All hot and cold water lines shall be thoroughly sterilised with a solution containing 20 parts per million of available chlorine in the form of liquid chlorine, sodium hypochlorite or chlorinated lime.

2. The sterilising solution shall be introduced into the lines in an approved manner and shall be kept in the pipe work for 24 hours, during which time all valves shall be opened and closed several times.

3. After sterilisation, the solution shall be flushed from the lines with potable water until the residual chlorine content is not greater than 0.2 parts per million, or as directed by the Engineer.

605.6 TESTING OF HVAC SYSTEM

605.6.1 Test procedures

Proposed test procedures for duct leak and performance tests of systems, shall be submitted to the Engineer at least 4 weeks prior to the start of related testing.

605.6.2 Test on completion

Prior to taking over, the Contractor shall conduct the following tests:

605.6.2.1 Testing, adjusting and balancing

Testing, adjusting, and balancing shall be as specified in ASHRAE and/or BRITISH STANDARD related to ADJUSTING AND BALANCING OF HVAC SYSTEMS. Testing and adjusting of ventilation systems shall begin only when the entire work has been completed, with the exception of performance tests.

605.6.2.2 Temperature test

Temperature tests during 10 hours minimum, all doors and windows being closed, the premises dry, and the outdoor temperature between 28°C and 34°C in summer and between - 2° C and + 6° C in winter. Inside temperature shall be measured at 1.5 meter above ground level. Supply and return air temperatures in air-conditioned premises shall also be measured.

605.6.2.3 Sound test

Sound level tests measured at 1.5 m from supply and extract gills by means of a variable frequency sound pressure level. Sound level shall not exceed 40 dBA.

605.6.3 Performance test

After testing and adjusting has been completed as specified, each system shall be tested as a whole to see that all items perform as integral parts of the system.
Correction and adjustments shall be made as necessary to produce the conditions indicated or specified. Capacity tests and general operating tests shall be conducted by an experienced engineer. Tests shall be carried out 4 weeks after all HVAC equipment has been put into operation successfully. Afterwards and after agreement with the engineer, the peak performance test shall be carried out at the time of peak outside conditions.
The equipment shall give the specified capacities at the peak conditions otherwise the equipment shall not be taken over.

605.6.4 Test reports

Test reports for the ductwork leak test and performance tests shall be submitted in booklet form, upon completion of testing. Reports shall document phases of tests performed including initial test summary, repairs/adjustments made, and final test results.

605.7 TESTING OF CHLORINATING SYSTEM

Prior to system start up all chlorination systems shall be pressure tested for leaks.

- The system shall be tested with nitrogen or dry air at a test pressure 50% higher than the service pressure. Soapy water shall be applied to all joints and connections to facilitates detection of leaks.
- The system shall be tested with chlorine. A rag soaked in liquid ammonia shall be brought to the vicinity of all potential leak points, leaks being evidenced by production of white ammonium chloride fumes. In the event of a leak, prior to effecting repairs, gas bottles shall be isolated and the lines drained through the dosing pumps.

IMPORTANT Procedure for Pressure Tests

1. Open all valves one turn except gas bottle valves.
2. Open gas bottle valves to achieve a system pressure of 1-2 kgf/cm^2 and close them again.
3. Search for leaks with an ammonia soaked rag.
4. In the event of a leak drain the lines with the dosing pumps and repair the leak.
5. Open gas bottle valves to achieve maximum system pressure.
6. Repeat 4 and 5 above.
7. When system is leak free open gas bottle valves one turn.

605.8 TESTING OF ELECTRIC, HYDRAULIC, CONTROL & TELEMETRY SYSTEMS

All tests shall be carried out according to BS 5772.

605.8.1 Testing of Electric Systems

- Time delay measurements of the units
- Insulation measurements of the various circuits
- Measurement of Resistance of Earthing bars
- Measurement of Voltage drops
- Measurement of Intensities conveyed through cables
- Measurement of Power consumption
- Correction of phases
- Measurement of Starting voltages, currents, etc...
- Measurement of Efficiency of Motors
- etc...

605.8.2 Testing of Hydraulic systems

- Surge protection
- Measurement of Pressure (upstream/downstream)
- Measurement of Flow
- Measurement of Efficiency of Motopumpsets
- Water analysis
- Valves
- etc...

605.8.3 Testing of Control & telemetry systems

- Communication links
- Safety
- Automatic operation, software
- Signals
- etc...

606. SETTING UP AND PRE-COMMISSIONING

Upon completion of works, and as soon as the equipment is ready to operate, the Contractor shall notify in writing the Engineer. The effective completion of the equipment assembling shall then be controlled in the presence of the Engineer and the Contractor by making the inventory of the equipment components. The good operation of all materials, especially of safety devices shall be checked.

The Contractor shall then set up the equipment.

During this period of "setting up", the Contractor can, upon the approval of the Engineer, stop or put in operation the equipment in order to make the necessary adjustments and be sure of their good operation.

When the Contractor deems that the equipment is ready to undergo the pre-commissioning operation, it shall be run for a period of time during which the equipment is operated according to a schedule set by the Engineer with the joint approval of the Contractor.

This period shall last fifteen days minimum, including, compulsorily, two days of continuous operation under the normal working conditions, as well as a number of successful consecutive startings to be agreed on with the Engineer.

During this period, equipment should operate without giving rise to any manufacture or setting up defect, that would lead compulsorily to putting them out of service. The Contractor can proceed to setting up operations during normal stop hours whenever he deems it necessary.

If, during this period, operating equipment give place to any incident, and, should the Contractor be bound to stop the equipment, outside normal stop hours, for any modification, setting up or adjustment, the period shall be extended to a duration equal to that of the interruptions.

In the same way, if the equipment should be stopped during the two days of continuous operation, the contractual period of 2 day continuous operation is counted all over again from the next starting.

Where frequent interruptions or the continuation of operation may cause any danger, the Engineer has the right to interrupt the operation, after having notified the Contractor. In this case, the Engineer gives the Contractor a delay reduced as much as possible and in accordance with the operation possibilities of the moment, to modify the equipment so that it conforms to the specifications of the Contract. After setting up defective parts, the equipment is put into service and the Contract during of the pre-commissioning period is counted all over again from that moment.

During setting up and operation periods, defined here above, the Contractor shall be responsible for the equipment. He shall overhaul, repair or carry out necessary modifications at his own costs.

607. TRAINING THE EMPLOYER PERSONNEL

During the period of assembling and especially during the period of pre-commissioning operation, the Contractor shall train the personnel assigned by the Employer. The training shall be carried out at 3 principal levels:

a) Engineers
b) Control and maintenance technicians (assistant engineers)
c) Skilled workers

The instruction of levels b) and c) shall be carried out with the collaboration of level a) already trained.

The training program, as well as the number of persons participating in the training shall be established by mutual agreement with the Employer, and upon his approval.

During the period of pre-commissioning, the Contractor shall hand over to the Employer's personnel the respective operating and maintenance manuals of the equipment.

608. COMMISSIONING

At the end of the satisfactory pre-commissioning operation, and if the Contractor has started training the Employer's personnel, the commissioning of the equipment shall start. It shall be deemed started and a report shall be drawn thereof provided that the Contractor has submitted to the Engineer a written request, along with a copy of the drawings, notices and documents necessary to the operation and maintenance of the equipment.

Starting from the commissioning operation, the Employer's personnel takes over the operation and the maintenance of the equipment under the supervision of a sufficient number of qualified technicians assigned by the Contractor.

These technicians shall supervise the personnel till the end of the commissioning.

The commissioning period is fixed to a minimum continuous duration of twenty eight days, during which the equipment shall function satisfactorily and require only minor secondary setting up or adjustment entailing no stops and revealing no systematic defect.

In case any setting up, adjustment or defect entails the stopping of the equipment during the commissioning period, the minimum period of twenty-eight days mentioned above should compulsorily restart as from the resumption of the normal commissioning operation.

During the commissioning period set above, the Contractor's supervising technicians shall continue training the personnel assigned by the Employer.

Until the taking over, and provided the operation requirements permit it, the Contractor shall carry out, at his own costs, all necessary replacements, modifications, setting up and adjustments.

609. TAKING OVER OF WORKS

After the end of the commissioning period and upon a written request submitted by the Contractor, it shall be proceeded, in the presence of the Engineer and the Contractor, to the taking over provided that the equipment has functioned without requiring more than minor setting up or adjustments and without showing any systematic defect or default occurring during the minimum continuous period of twenty-eight days, and not in conformity with the technical specifications set in the tender document.

Taking over should include an inventory of the equipment and the tests set in the technical specifications, in order to verify whether the equipment meet, in quantity and quality, the conditions of the Contract.

The date and the schedule of the Taking Over are fixed by mutual agreement between the Engineer and the Contractor.

The Contractor shall carry out all necessary works and installations, and supply and assemble the equipment used for tests.

The Contractor is bound to inform the Engineer of all the defects he has detected.

In case operation incidents occur before taking over, the Engineer shall reserve the right to ask for an exhaustive inspection of the main components (pumps, motors, etc...).

The taking over shall be the subject of reports mentioning the necessary repairs and setting up.

The tests carried out eventually by the Contractor during the periods of setting up and commissioning shall not be taken into consideration and shall be carried out once again during execution of the official tests on completion.

In case part of the equipment is rejected under any condition set hereafter in section “Rejection Of Equipment”, the taking over of equipment, which is not rejected and is in accordance with the taking over conditions, is declared, provided that the equipment can be used independently from the rejected part.

Taking over takes place after achievement of satisfactory tests on completion.

The taking over shall be the subject of a report signed by the two parties.

It is agreed that, in case taking over is not declared, equipment remain under the responsibility of the Contractor.

Consequently, the Contractor shall bear along the consequences of all incidents or accidents occurring to the equipment before the signature of the taking over certificate.

The equipment shall, in no case, be considered as commissioned de facto.

610. DEFECTS LIABILITY PERIOD

The Contractor guarantees that all the supplies delivered according to the terms of the Contract are new, have never been used, are of the latest pattern put into service and have undergone all necessary improvements relating to design and materials.

Moreover, the Contractor guarantees that all the delivered supplies have no defects owing to their design, to the constituent material or to their use.

The Defects Liability Period remains valid for 12 months as from the date of Taking Over.

During the Defects Liability Period the Contractor shall supervise the maintenance of the installations.

During the Defects Liability Period, the Contractor is bound to carry out all modifications, setting up, adjustments required for the replacement of the defective parts, so that the equipment meet the conditions set out in the Contract.

If during the Defects Liability Period an equipment is stopped due to defects attributable to the Contractor, especially in the case of abnormal wear, deterioration or misfunction of a main component, the Defects Liability Period for this equipment is extended to cover the period of time during which the equipment was out of order.

If during the Defects Liability Period, it is necessary to replace a component due to an abnormal wear, deterioration or misfunction, the Defects Liability Period of this component is counted from the moment the replacing parts are put into service. In this case, the Engineer can, at the end of the Defects Liability Period retain an amount of money equal to twice the price of the component determined at the moment of the replacement. This amount shall not be fully paid up until the end of the Defects Liability Period proper to this component, provided that the latter was proved consistent with the clauses of the Contract.

The Contractor affords all the expenses resulting from the above-mentioned operations including the cost of transportation, on site disassembling and reassembling and customs dues, etc...

Are excluded, expenses resulting from a deterioration owing to a negligence or an operation error and attributable to the Employer, or due to operation conditions that are not consistent with the instructions of operation and maintenance given by the Contractor. After having examined these defects not attributable to him, the Contractor shall inform the Engineer within a period of ten working days only, under a penalty of foreclosure.

The Contractor is not responsible for the components supplied, repaired, modified or replaced by the Employer or his representative without the written approval of the Contractor. However, this does not include the cases where the Employer carries out urgent repairs or replacements in the event of non compliance by the Contractor to the conditions mentioned hereinafter.

If it has been proved that the noticed defect is caused by a systematic error of design of equipment, the Contractor should replace or modify all identical parts used on the other equipment mentioned in the Contract, even though they did not give rise to any accident.

All works incumbent on the Contractor during the Defects Liability Period should be executed as soon as possible, taking into consideration the operation requirements.

The Contractor should, however, afford all provisional repairs to meet to the best these requirements, while reducing to the minimum the time during which equipment is partially or totally not operational.

The end of the Defects Liability Period will be declared following satisfactory Test On Completion results.

611. MAINTENANCE SUPERVISION DURING THE DEFECTS LIABILITY PERIOD

From the provisional taking over and till the end of the Defects Liability Period of all supplies, the Contractor shall ensure:

– the supervision of the maintenance of the installations carried out by competent technician

– the supervision of the necessary check-ups. The Employer shall bear the cost of workmanship, except those of the contractor's technicians.

– the supply of necessary spare parts. Therefore, the Contractor shall store on site all spare parts required for operation during the Defects Liability Period.

– the follow up and the further training of the Employer's personnel, as regards the operation and maintenance of the installations.

612. REJECTION OF EQUIPMENT

The Engineer reserves the right to reject the equipment under any of the following conditions:

a) If during the period of installation and assembling, several components of any equipment are discovered to be defective.

b) If the Tests On Completion show deviations with regard to the required flow and efficiency values specified in the Particular Specifications at the TDH.

c) If, during the Defects Liability Period serious defects occur (not allowing a safe operation and unlikely to be repaired by the Contractor within reasonable delays).

The Engineer can only reject the entire equipment if it shows serious defects which make its use dangerous or very expensive.

In the other cases, only the parts (of an entire machine) not answering the conditions of the Contract are rejected.

Before declaring the rejection, the Engineer shall examine, according to the elements submitted by the Contractor, the possibilities of :

a) either limiting the rejection to the seriously defective parts.
b) or fixing a delay to overhaul the equipment so that it meets the conditions of the Contract.

The Engineer may allow replacing the rejected equipment at the expense of the Contractor, during this time, he can:

– either renounce using the rejected equipment,

– or, use the equipment under the responsibility of the Contractor and upon his approval, on condition that several modifications, adjunctions or eventual adjustments are carried out, at the expense of the Contractor, either by him or by a supplier, if any. Therefore, the Engineer can, gratuitously, use the rejected equipment, and undertake to use it under the normal operation and maintenance conditions.

In all the cases mentioned above, rejected parts are returned to the Contractor.

613. OPERATION AND MAINTENANCE MANUALS

The Contractor shall supply for each set of installations provided for in the Contract, bilingual Operation and maintenance manuals (Arabic, French or English).

They shall include a table of contents and complete relevant material to the following sections as a minimum:

- Warnings
- General description
- Pumps control and protection
- Pumping station start up procedure and run operation
- Settings
- Preventive maintenance
- Trouble-shooting procedure
- Bill of material
- Drawings
- Manufacturer catalogues.

Unless otherwise specified, the instructions and the documents thereto shall be supplied in 3 copies properly presented and protected.

نظمه	دقّقه	موافق
المكتب الفني للإنماء (BTD)	رئيس مصلحة الدروس بالإنابة	مدير المياه بالإنابة
ميشيل مجدلاني	المهندس علي الخطيب	المهندس منى فقيه

موافق	صدق
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