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1. MECHANICAL WORKS

1.1 Workmanship and Design of Plant

1.1.1 General

This section of the Specification sets out the general standards to be adopted and mention of any specific material or plant does not necessarily imply that such is included in the works.

All component parts of the works shall, unless otherwise required in the Contract, comply with the provisions of this section.

The names of the manufacturers of materials and equipment proposed for incorporation in the works together with procedures, performances, capacities, certified test reports and other significant information pertaining to the same, shall be furnished when requested for consideration by the Employer, who shall have power to reject any parts which, in his opinion are unsatisfactory or not in compliance with the Specification and such parts shall be replaced by the Contractor at no extra cost to the Employer.

The design, construction and layout of the plant and equipment shall be such as to ensure safety, simplicity and ease of operation, plus economy in maintenance. The plant shall be new, of sound workmanship and robust design.

The general electrical and mechanical design of the plant and particularly that of bearings, contacts and other wearing parts shall be governed by the need for long period of service without frequent maintenance and attention by the owner being necessary. Design aspects offering long service life should be highlighted in the tender submission.

Where practicable all installations shall be indoor and in a dry position. Where a choice of location exists between an indoor and an outdoor location, an outdoor location will not be permitted. Outdoor installations shall be weather proof, protected against accidental and malicious damage and designed to prevent the collection of water at any point.

Unless otherwise required in the contract all items of plant shall be rated for continuous service at the specified duties under the prevailing atmospheric and operational conditions on site. The conditions under which the plants are required to operate are known to vary throughout the year. The conditions can be arduous with excesses of heat, dust, rainfall and humidity. Reference ambient temperature of design of all electrical equipment is 45 degrees Celsius.

All Plant shall operate with minimum noise and vibration. All rotating parts shall be truly balanced both statically and dynamically so that when running at normal speeds and any load up to the maximum there shall be no vibration due to lack of balance. Full speed shall be less than the first critical speed.

All component parts shall be manufactured to a strict system of tolerances and complete interchangeability of similar parts is required. All wearing parts shall be

readily available within Sri Lanka. If not, they shall be listed in the tender as additional mandatory spares and sufficient spares for a period of five years priced within the schedules.

All parts subject to wear shall be readily accessible.

Ball and roller bearings shall be interchangeable with similar items from alternative makers. Parts lists shall include alternative reference numbers and makers and spares must be readily available within Sri Lanka. If not this should be made clear within the tender return and the nearest countries of stockists listed. They shall have a minimum running life of 70,000 hours for the duty loading. All bearings shall be to ISO standard SI unit dimensions where practicable.

All submerged moving parts of the Plant, pins, spindles, shall be of non-corrodible metals. All parts in direct contact with chemicals shall be completely resistant to corrosion or abrasion by those chemicals, and shall also maintain their properties without ageing due to the passage of time, exposure to light or any other cause.

All holding down, alignment and levelling bolts, anchorages, nuts, washers and packings shall be provided to attach the Plant to the foundations. All bedplates, frames and other structural parts shall spread the loads transmitted by the Plant to concrete foundations. The making good and grouting of bedplates and supports and the construction or modification of concrete plinths is included.

Where during the warranty period any moving parts show, in the opinion of the Employer, signs of undue wear or unsuitability for the purpose for which they are installed, they shall be replaced, at no cost to the Employer, notwithstanding that they may otherwise be working in a satisfactory manner.

All warning signs, notices, other signs, labels and the like shall be provided by the Contractor in English, Sinhalese and Tamil languages.

1.1.2 Plant Fixing

All fixings shall be sized to suit the loading and duty of the attached item.

Fixing to brickwork or block work shall be made in the bricks or blocks and not in the joints. In external and damp situations equipment shall be secured to brickwork and block work by round headed stainless steel woodscrews and plastic wall plugs. Other indoor fixings shall be secured with stainless steel anchor bolts. Mounting fixings shall comprise straps or external lugs. Accessories mounted in fixed equipment shall incorporate slotted fixing holes.

All equipment shall be fixed with purpose-made clamp brackets, or proprietary fixing bolts. Plugs or shot bolts shall NOT be used without the written approval of the Employer.

No structural steelwork shall be drilled for any purpose without the written approval of the Employer. In general all fixings to steelwork shall be by means of studs welded to the steelwork or by clamp-brackets or hook bolts. Exterior steelwork fixing shall be galvanized.

Machinery shall be mounted on flat steel packing of thickness selected to take up variations in level of the concrete foundations. One packing only of selected thickness shall be used at each location which shall be adjacent to each holding down bolt. The number of shims used with each packing shall not exceed two at each location and the thickness of each shim shall not exceed 3 millimeters.

Grouting of holding down bolts shall be carried out before the machinery has been run and checked by the Employer for stability and lack of vibration. Final grouting of shims etc. shall be carried out only after the aforementioned run and check by the Employer has been completed, approval given, and the grouting area cleaned.

1.1.3 Labelling

All labelling shall be in English, Sinhalese and Tamil. Each main and auxiliary item of Plant shall have permanently attached to it in a conspicuous position a rating plate of weather- resistant material. The Manufacturer's name, type and serial number of Plant, details of the loading and duty at which the item of Plant has been designed to operate shall be engraved on each plate. Where the Plant may have its rating plate in an inconvenient position (e.g. submersible pumps) then the Contractor shall supply an additional plate summarizing the particulars, which shall be fixed in a suitable location on the operating platform.

The labels shall be of non-corrodible metal embossed with the lettering or traffolyte engraved type with black letters on white background and shall be fixed with brass or stainless steel screws. The labels shall be conspicuous and consistently located relative to the equipment to which they apply so that they can be read from the normal operating positions.

Where tanks or vessels contain chemicals they shall be labelled with the chemical name with letters not less than 150mm high together with a HAZCHEM storage sign in statutory colours.

The label character sizes shall be selected with regard to the maximum distance at which the label must be read and the ambient lighting conditions.

All safety signs shall comply with ISO 3864 or equivalent.

Plant which may start automatically shall carry labels (minimum size 200mm x 100mm) incorporating a hazard warning symbol and the following wording and the Sinhalese and Tamil translation in black letters with yellow background:

"WARNING - THIS PLANT IS REMOTELY/AUTOMATICALLY CONTROL AND MAY START AT ANY TIME"

A metal "Emergency Resuscitation Treatment" notice (approx. 600mm x 400mm) and "Electricity at Work Regulations (1989)" notice (approx. size 750mm x 500mm) shall be appropriately mounted in each electrical control room.

1.1.4 Shafts, Couplings & Gearboxes

The allowable maximum rotation speed is 1450 rpm. In the case of optimum selection requiring 3000 rpm drive, an alternative selection running at 1450 rpm (if possible) shall also be priced using duplicates of the schedules and questionnaires.

The drive coupling shall be rated to transmit the maximum rated motor power output. All transmissions and couplings shall be erected true to line. The coupling shall correct minor angular and positional misalignment without allowing resultant "strain energy" stressing of either driver or driven shaft. The coupling shall be key located on each shaft, and easily removable.

Shafts shall be of high tensile steel or stainless steel. To reduce stress concentrations, section changes on the shaft shall be properly radiused at the root of any steps and keyways shall be internally radiused or gradually run out. The shaft shall have first critical speed well above maximum operating speeds. 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 items 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 realignment can be easily achieved when reassembling the items after removal for overhaul.

Where fitted bolts, spigots or other means for precise location are not employed in the assembly of the plant, locating dowels shall be fitted on completion of erection and alignment. Fitted bolts shall be identified by means of stainless steel tags installed under the bolt head.

Standard enclosed gear boxes for machines shall be obtained from an approved manufacturer. Couplings shall be of the flexible multi-pin and bush type. Bosses shall be a tight fit on the shafts and secured with hand fitted stainless steel keys.

Belt and chain drives shall be provided with separate independent means for adjustment of tension and alignment.

All gear boxes shall be suitable for outdoor installation and shall be derated to take account of continuous operation and heavy shock loads. Service factor shall not be less than 2 for a 40 ^{o}C ambient temperature.

Gear box housings shall be of rigid high-strength close grained cast iron and shall be complete with ventilation opening and oil level gauge.

The transmission of power shall be achieved by means of precision helical gears and the gearbox designed for a guaranteed life span of at least 100,000 hours.

The gear box shafts shall be solid forgings of the parallel type, precision ground and made from heat treated hardened and tempered chrome-molybdenum alloy steel.

1.1.5 Vibration

Mechanical vibration levels at duty point conditions shall be in accordance with the requirements of ISO 2372 for range of vibration severity.

1.1.6 Guarding of Shafts

All rotating shafts, couplings, gears, flywheels, bolts, drives etc shall be fully guarded to BS 5304 or equivalent.

Guards shall be designed to provide ready access to bearings, greasing points and other check points to allow routine observations to be made by the operating staff without danger or the need to dismantle any part of the guard. Hinged doors let into the guards with adequate fastening shall be provided where necessary to facilitate access to the check points. Openings giving access to rotating parts shall be such that the standard test finger as illustrated in BS 5490 Fig. 1 or equivalent when inserted through any opening does not touch any moving part.

1.1.7 Bearings

Bearings must be capable of taking all radial and axial loads resulting through the normal and extreme conditions. Class of fit, bearing clearance classification shall be indicated in the technical schedules.

1.1.8 Materials

All materials utilized in the plant shall be the most suitable for the duty concerned and shall be new and of first class commercial quality.

Particular attention shall be paid to material selection to minimize corrosion due to atmospheric conditions, contact with or submersion in corrosive liquids, electrolytic action of dissimilar metals, or any other causes which may reasonably be associated with the overall performance of the Works.

The use of organic materials shall be avoided whenever possible but where they have to be used they shall be treated to make them fire resistant and non-flame propagating.

The use of wood is to be avoided wherever possible but where this has to be used, all woodwork shall be treated to protect it against damage by fire, moisture, fungus, bacteria or chemical effect, unless it is naturally resistant to these causes of deterioration.

1.1.9 Contact with Potable Water

All materials used in contact with potable water shall be as approved by the UK Committee on Chemicals and Materials of Construction in Public Water Supply and Swimming Pools (CCMC) and listed as a substance, product or process approved under Regulations 25 & 26 for use in connection with the Supply of Water for Drinking, Washing, Cooking and Food Purposes by the Drinking Water Inspectorate (DW1) in accordance with the Water Supply (Water Quality) Regulations 1989 amended 1991.

A list of materials that are approved is published annually by the DW1.

1.1.10 Castings

All castings shall be of standard grey close grained cast iron to BS 1452 or equivalent Grade 220 or better and be sound and free from defects, non-metallic inclusions or blowholes. All non-machined surfaces shall be carefully fettled and all foundry irregularities removed.

Details of any remedial action it is proposed to utilize for the repair of castings must be submitted to the Employer in writing for approval.

1.1.11 Forgings

All major stress-bearing forging shall be made to a standard specification, and be subject to internal examination, non-destructive tests for the detection of flaws and heat treated fix the relief of residual stresses.

The Employer may inspect forgings at the place of manufacture with a representative of the Contractor.

1.1.12 Stainless Steel

Stainless steel shall have a resistance to atmospheric corrosion not less than that provided by BS 970 or equivalent Grade 316 S13 or by BS 1501 or equivalent Grade 316 S12.

1.1.13 Aluminium Alloy

Aluminium structural supporting members shall be fabricated from HE-30-EP aluminium alloy, which shall comply with ISO 209/2;3;4, as appropriate for the sections, plate, sheet and other forms employed.

1.1.14 Welding

Welded joints in steel pipes shall be butt welded, carried out manually by the metal-arc process complying generally with the requirements given in SECTION 1.11.10(c) WELDING.

Welding shall be carried out only by welders approved by the Employer.

Before starting the welding of pipe joints the Contractor shall submit for the Employers approval details of the equipment, methods and materials he proposes to use, including make and size of electrodes, number of runs and current strength.

Contractor shall employ only skilled welders and submit for the Employer's approval the names of persons whom he proposes to employ as welders. The Employer may require any such person to perform satisfactory test welds under Site conditions and on pipes similar to those for use in the Works, before approving his employment as a welder. The Contractor shall maintain an up-to-date list of welders approved by the Employer and if ordered by the Employer shall remove from the

approved list any welder whose Workmanship is below a reasonable standard of quality or consistency in the Employer's opinion.

All welding shall be carried out in accordance with the current relevant British Standard or Code of Practice.

In all cases where welds are liable to be highly stressed before fabrication commences, the Contractor shall supply the Employer with detailed drawings of all welds and weld preparations proposed. No such welding shall be carried out before the Employer has signified his approval.

Welded components containing highly stressed fusion welds shall be stress relieved prior to machining. A smooth neat finish, by careful grinding if necessary is required on all exterior welding and shall be free from pitting or slag inclusions.

Radiographic examination or other non-destructive testing of welds may be ordered by the Employer and the Employer may witness such tests.

Other welds shall be subject to dye or magnetic particle penetrant testing.

Evidence of the valid certification of the welding personnel may be requested by the Employer where necessary in accordance with BS 4872 or equivalent.

1.1.15 Nuts, Screws, Washers, Bolts and Anchors

Nuts, screws, washers and bolts shall comply with the relevant requirement of the following ISO standards unless otherwise specified:

- ISO 272
- ISO 885
- ISO 888
- ISO 4759

Bolting for pipes and fittings shall comply with ISO 7005/2 except that spheroidal graphite iron bolts for use with ductile iron pipes and fittings shall be steel, galvanized to ISO 1459; ISO1460; ISO1461 or equivalent or sherardised to BS 4921 Class I or equivalent.

All bolts, nuts and washers which are liable to become submerged during the operation of the plant shall be nickel-chromium stainless steel. (Minimum quality 316 S13 to BS 970 or equivalent) All other threaded fixings, washers etc. shall be hot dipped galvanized to ISO1459, ISO1460 and ISO1461.

One washer shall be provided under each bolt head and nut.

Bolt clearance holes shall be drilled, never flame cut.

Anchor bolts shall be either sleeve type or of encapsulated epoxy resin bonded type. They shall be of stainless steel with a minimum ultimate tensile strength (UIS) of 540 MN/m^2. The use of hook bolts or similar grouted into preformed pockets is not permitted.

All exposed bolt-heads and nuts shall be hexagonal and the length of all bolts shall be such that when fitted with a nut and tightened down, the threaded portion shall fill the nut and not protrude from the face thereof by more than one thread or 1/2 a diameter whichever is the least.

1.1.16 Special Tools

Any special tool provided for maintenance of the Plant in each town shall be identified within the tender and supplied and handed over to the Employer on completion of the Works. Prior to handover the Employer and Contractor shall examine tools which have been used during plant erection to ensure that they are not damaged and are in good condition.

The recommended optional tools, including any special tools, gauges, jigs or extractors which may be required for maintenance of the Plant shall be set out in the appropriate schedule. A suitable lockable box shall be provided for each town to contain all tools provided.

1.1.17 Lubrication

The initial changes of oils, greases, electrolyte and similar materials necessary for the correct setting to work and operation of the plant shall be included in the Contractor's price. All lubricants shall be readily available within Sri Lanka.

A complete schedule of recommended oils and other lubricants shall be furnished by the Contractor, for approval by the Employer. The number of different types of lubricants shall be kept to a minimum. In the case of grease lubricated roller bearings for electric motors a lithium base grease is preferred. A draft of this schedule with trade names, purpose, viscosities, etc. container size and life, and the name of the manufacturer (preferably one only) and his local Contractor shall be incorporated in the draft operation and maintenance instructions.

Where lubrication is effected by means of grease, a pressure system shall be provided which does not require adjustment or recharging more than once weekly and a grease system having a shorter period between greasing is not permitted. Where necessary for accessibility, grease nipples shall be placed at the end of extension pipes and when a number of such points can be grouped conveniently, the nipples shall be brought to a battery plate mounted in a convenient position. 'Hydraulic' button head nipples shall be used for normal grease. The nipple, which shall be unpainted, shall be an alloy of brass or similar non-corrosive material. Arrangements shall be provided to prevent bearings being overfilled with either grease or oil.

When more than one special grease is required at a site a grease gun for each special type shall be supplied for that site and permanently labelled.

Oil sumps shall be fitted with oil level indicators of the sight glass type or, where this is not practicable with dipstick indicators which shall show the level at all temperatures likely to be experienced in service. The normal maximum and minimum levels at 30 degrees C shall be clearly visible in the sight glass from the normal access floor adjacent to the particular item of plant.

All lubrication systems shall be designed so as not to present a fire hazard and particular care shall be taken to prevent leakage of lubricant.

The Contractor shall supply flushing oil for each lubrication system when an item of plant is ready for preliminary running, and a sufficient quantity of the approved lubricants for setting to work for the commercial operation of the plant for one year after issue of the Taking-Over Certificate.

1.1.18 Colour Coding For Water Supply

Pipes, valves, pumps, compressors etc shall be colour coded in accordance with Table 5.1.1.18 below. The coding shall indicate the contents of the pipelines, purposes of the valves etc, and show whether or not the fluids being handled are dangerous.

Tape banding of pipes, of the appropriate colour, shall be spaced at 3 m intervals and at every valve or junction, direction of flow arrows shall be provided together with process stream contents.

Lagged pipework shall be colour coded prior to lagging. Lagging surface shall be continuously colour coded.

Stainless steel shall not have any paint system applied to its surface but imperfections and heat affected zones shall receive a suitable treatment to give a high quality uniform surface appearance.

TABLE 5.1.1.18 Colour Coding For Water Supply

COLOUR	BS 4800	WATER	SEWAGE
VIOLET ORANGE PINK	22C37 08E51 04C3	Acids/Alkalis etc Chlorine Gas	Acids/Dangerous Digestor Gas
YELLOW LIGHT BROWN SILVER	10E53 08C35 10A03	Natural Gas Fuel Oil Steam	Natural Gas Fuel Oil -
WHITE LIGHT BLUE DARK BLUE	00E55 20E51 20D45	Sulphur dioxide Compressed Air Instrument Compressed Air Process	Oxygen Compressed Air Instrument Compressed Air Process
DARK GREEN OLIVE GREEN LIGHT GREEN+ AUX BLUE	14C39 12D45 14E51± I 8E53	Raw Water. Partially treated water Potable Water	Raw Sewage/Final effluent Boiler Feed waler Potable Water
DARK BROWN BLACK	06C39 00E53	Filter wash water etc Consolidated Sludge	Raw Sludge Treated or Digested Sludge
RED GREY MID BLUE	04E53 8I325 I 8C39	Hot Plant, Boiler Casings, Flues etc. Motors, Gearboxes, Transmissions Structural Steel, Frameworks.	Hot Plant, Boiler Casings, Flues etc. Motors, Gearboxes, Transmissions. Structural Steel, Frameworks.

1.1.19 Protection & Packaging

A) Cleaning and Protection at Place of Manufacture

Parts shall be cleaned prior to testing at the Manufacturer's Works. Parts subject to hydraulic test shall be tested before any surface treatment. After testing all surfaces shall be thoroughly cleaned and dried out prior to surface treatment.

Bright parts and bearing surfaces shall be thoroughly polished and protected from corrosion by the application of rust preventative lacquer or high melting point grease before the parts are packed. A sufficient quantity of the correct solvent for removal of the protective compounds shall be supplied and packed with each particular part.

B) Protection. Packing and Transportation

Before any plant is dispatched from a manufacturer's works it shall be properly prepared and packed and the Contractor shall give the Employer at least 14 days notice that these preparations are to commence.

Prior to dispatch from the Contractor or Manufacturer's premises all plant shall be adequately protected by painting or by other approved means for the whole period of transit storage and erection, against corrosion and incidental damage.

The flanges of the pipes, valves and fittings shall be protected by wooden discs attached by means of service bolts (which shall not be used at Site) or by other approved means. The sleeves and flanges of flexible couplings shall be securely

tied. Cases containing rubber rings, bolts and other small items shall not normally weigh more than 50 kg gross.

All items of plant shall be clearly marked for identification against the packing list.

Every crate or package shall contain a packing list in a waterproof envelope. A duplicate copy of the packing lists shall be sent to the Employer.

All crates, packages etc., shall be clearly marked with a waterproof material to show the weight and where the slings should be attached and shall also have an indelible identification mark relating them to the packing lists.

The Contractor shall be responsible for making all the arrangements necessary for the transportation of equipment and plant to site including investigation of the route for bridge clearances, loading etc.

C) Spare Parts

All spare parts supplied shall be treated and packed for long storage in an unheated and uncooled store in a humid atmosphere. Each spare part shall be clearly marked or labelled on the outside of its packing with its description and purpose and when more than one spare is packed in a single case a general description of its contents shall be shown on the outside and a detailed list enclosed.

1.2 Pipes and Fittings

1.2.1 References

Pipes and fittings shall comply with the relevant provisions of the appropriate ISO Standard or equivalent as set out below:

(a)	Ductile Iron pipes and fittings	ISO 2531; 4179; 8179
(b)	Steel pipes, specials and fittings	BS 534, 3600, 3601, 1640, 1965
(c)	Metal arc welding of steel pipes	BS 2971
(d)	Screwed pipes & fittings for pressure	ISO49, BS1256. ISO65
	Purposes for water, air and oil	ISO445
(e)	uPVC pipes and fittings	SLS 147
(f)	ABS pipes & fittings	BS 5391, BS 5392
(g)	Copper pipes and fittings	ISO 2016, BS 2871
(h)	Polythene pipes	BS 1972
(i)	Nylon Tube	ISO 7628 Part 1
(j)	Pipe Flanges	ISO 7005/2/3
(k)	Rubber hoses for use with compressed air	ISO 2398
(l)	Rubber hoses for use with potable water	ISO 1403
(m)	Pipe supports of fabricated steel	BS 3974

Materials and coatings used shall be unconditionally resistant to the conveyed fluids.

Pipework shall be as follows:

(a) Potable Water (including supernatant) -
Pumped-Ductile Iron Cement Mortar Lined or Coated Steel.
Gravity - Polyethylene, Polythene, uPVC

(b) Drainage - uPVC or reinforced concrete

(c) Sludge - Ductile Iron or Coated Steel or (a)

(d) Sampling - uPVC, ABS or stainless steel

(e) Air - Galvanized Mild Steel or ABS.

(f) Instrumentation - copper tubing (PVC sleeved)

1.2.2 General

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

Pipes and fittings shall be compatible and have equal or higher pressure ratings as specified.

Pipes, fittings and appurtenances shall be installed in full conformance with the manufacturer's recommendations.

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

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

At the conclusion of the work the Contractor shall clean all piping and pipelines as specified in SECTION 8.3.2. CIVIL ENGINEERING AND BUILDING WORKS, 1.10.7 “TESTING AND DISINFECTION”.

1.2.3 Pressure Rating

Pipework and fittings shall be suitable for a safe working pressure equivalent to the maximum working pressure of the system. The safe working pressure of pumping mains shall be the closed valve head of the pump plus the maximum suction static head. The pipework shall also be rated for the maximum surge pressures generated in the system.

Ductile iron pipework and fittings shall have a minimum pressure rating of 16 bar.

1.2.4 Design

All machinery stations shall be provided with flexible joints, flange adaptors or unions such that upon renewal of plant minimal disturbance of pipework is required.

The pipework system shall be so designed to ensure that anchorage at blank ends, bends, tees and valves may be kept to a minimum. The Contractor shall provide and install all anchor blocks and mechanical ties required to support and accommodate system thrust loadings unless otherwise stated.

There shall be a sufficient number of mechanical joints to enable mechanical plant and valves to be disconnected from built-in pipework. Such joints shall be tied, as required to counter hydraulic loadings and shall not be allowed to sustain the weight of any pipework.

Flanges shall be drilled off centres.

Pump suction bell mouths shall be standard castings in either cast iron or ductile iron.

The use of gusseted bends shall only be permitted upon approval by the Employer. Where space allows all bends shall be even curvature manipulated bends and where short radius bends are required the use of carbon and alloy steel welding fittings to BS 1640 Part 3 or equivalent shall be permitted.

Tee pieces on pump manifolds shall have a radial branch to enable a more streamlined flow from branch to body. Short radius tee pieces are permitted where there are space limitations and the consequent head toss is insignificant. Due allowance shall be made to provide reinforcement in the vicinity of branches etc.

Puddle flanges shall be provided on all pipes where they pass through pumping station walls. The Contractor shall provide and ensure a gas tight seal at the penetration.

Pump suction and delivery manifolds shall be provided with a drain valve and a station isolating valve.

Where pipes pass through a concrete wall or structure they shall, where space permits project from the external face(s) of the structure by 300mm for pipes with nominal bores of 500 mm or less and by 500mm for pipes with nominal bores in excess of 500 mm and the surface of such pipes shall be prepared to the approval of the Employer to ensure a satisfactory bond between pipes and concrete.

Flat top eccentric tapers shall be used to connect suction pipework to pump flanges.

Where pump sets are installed with suction water levels below the center line of the pump set the pipework shall include a manually operated priming connection between the delivery main and the suction main.

Where removable screens are not installed to protect raw water pump inlets, strainers shall be provided and fixed to the bell mouth end of each suction pipe.

Strainers shall have perforations of 12 mm dia. and total area of openings shall not be less than that of the larger end of the bell mouth. The surface area of strainers shall not be less than 4 times that of larger end of the bell mouth. Strainers shall be fabricated of bronze plate of minimum thickness of 10 mm.

Baffle walls to separate suction pipes shall be provided to prevent turbulence and direct the flow of water to the bell mouth in a streamline manner.

Due allowance shall be taken into account of the NPSHA at pump installations and allowed for in the pump selection.

1.2.5 Velocities

Allowable velocities in pipes will be related to the fluid type and shall comply with the following.

Fluid	Minimum	Maximum
Raw Water	0.5 m/s	2.0 m/s
Potabal Water	N/A	2.5 m/s
Backwash Water	N/A	2.0 m/s
Pre-cake sludge	0.8 rn/s	1.5 m/s
Sewage	N/A	0.8 m/s
Air	N/A	15.0 m/s

1.2.6 Flange Adaptors

Thrust shall not be transmitted through flange adaptors and alignment shall be within the manufacturer’s tolerance.

Where “tying” of flange adaptors is impractical, fixed slip-on flanges are permitted provided the Contractor provides other means of support such as thrust blocks.

1.2.7 Handling

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

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

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

All pipes shall be bundled or packaged in such a manner as to provide adequate protection for the ends, threaded or plain, during transportation from the

manufacturer to the Contractor. All special provisions for ocean shipment shall be provided.

1.2.8 Inspection

The quality of all materials, the process of manufacture, and the finished piping shall be subject to inspection and approval by the Engineer by an independent testing laboratory selected by the Employer, or by other representatives of the Employer. Such inspection may be made at the place of manufacture or at the site after delivery, or at both places, and the pipe shall be subject to rejection at any time on account of failure to meet any of the specification requirements, even though sample pipes may have been accepted as satisfactory.

Inspections, at point of manufacture, will require the Contractor's and manufacturer's cooperation. The cost of foundry or factory inspection of piping approved for these works will be in accordance with the program set forth under the Provisional Sums.

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

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

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

1.2.9 Flanged Joints

Flanged joints shall be furnished complete with gaskets, bolts and nuts.

Gaskets shall be cut to the proper size so that no part protrudes. Prior to application of gaskets, the face of the flanges shall be thoroughly cleaned.

All gaskets supplied with each flange fitting shall be styrene butadiene rubber (SBR) conforming to BS 2494. Thickness of gasket shall be 3mm.

Flange assembly bolts shall be standard hexagon head machine bolts with hexagon nuts. Threads shall conform to ISO 68, "ISO General Purpose Screw Threads-Basic Profile". Material for bolts and nuts shall be steel conforming to ASTM or BS or other internationally accepted standards, and shall have a minimum yield strength of not less than 226 N/mm^2. Steel bolts and nuts shall be galvanized. Bolts and nuts for intermittent or continuous underwater pipe work shall be Type 304 stainless steel. Bolts and nuts for stainless steel flanges shall be stainless steel and type of stainless steel shall be the same as the flanges.

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

The bolts shall not protrude more than 3 mm beyond the nuts. Should the bolts protrude more than 3 mm, the bolt ends shall be machined cut and refinished.

Mating dimensions of flanges, nominal diameter 80 mm to 1,800 mm shall conform to dimensions shown on the following FLANGE SCHEDULE. Mating dimensions and thicknesses of flange, nominal diameter 65 mm and smaller shall conform to ISO, ANSI, or BS or internationally accepted standards and the working pressure of the flange shall be 0.98 MPa.

FLANGE SCHEDULE

(Dimensions in Millimeters)

NOMINAL DIAMETER			**DIAMETER BOLT**	**DIAMETER**	
DN	**D**	**C**	**NUMBER**	**d**	
80	200	160	8	19	16
100	220	180	8	19	16
150	285	240	8	23	20
200	340	295	12	23	20
250	400(405)	355	12	28	24
300	445(460)	410	12	28	24
350	520	470	16	28	24
400	580	525	16	31	27
450	640	585	20	31	27
500	715	650	20	34	30
600	840	770	20	37	33
700	910	840	24	37	33
800	1025	950	24	40	36
900	1125	1050	28	40	36
1000	1255	1170	28	43	39
1100	1355	1270	32	43	39
1200	1485	1390	32	49	45
1400	1685	1590	36	49	45
1500	1820	1710	36	56	52
1600	1930	1820	40	56	52
1800	2130	2020	44	56	52

Definitions: DN - Nominal diameter of pipe
D - O.D. of flange
C - Diameter of bolt circle

d - Diameter of bolt holes.

( ) - Only for steel flange

Note: Bolt holes shall straddle the vertical center line of the flange.

1.2.10 Ductile Iron Pipe

(a) General

Ductile iron pipes and fittings, joint materials and accessories shall be manufactured in accordance with all provisions specified hereinafter and on a single standard. Outside diameter of pipes and fittings in all sizes shall conform to ISO. All dimensions of joints of pipes and fittings shall also be in accordance with a single standard and all provisions specified hereinafter.

(b) References

The following standards are referred to.

ISO 2531	Ductile Iron Pipe, Fittings and Accessories for Pressure Pipelines
BS 4772	Mortar Lining of Ductile Iron Pipes for Water Works
BS EN 1563	Spheroidal Graphite Iron Castings
BS EN 598	Ductile Iron Pipes, Centrifugally Cast for Water Works
BS 2494	Elastomeric Seals for Joints in Pipeworks
AWWA C104	Cement-Mortar Lining for Ductile- Iron Pipe and Fittings for Water

(c) Pipes

Ductile iron pipes shall exhibit the physical characteristics as given

The pipes shall conform to ISO 2531 and its full length shall not exceed six (6) meters. The pipe shall be manufactured by the centrifugal casting method. The pipe, unless otherwise specified, shall have a minimum wall thickness and outside diameter as stipulated in the following schedule:

SCHEDULE OF MINIMUM WALL THICKNESS AND OUTSIDE DIAMETER OF DUCTILE IRON PIPES

NOMINAL DIAMETER (mm)	MINIMUM WALL THICKNESS t (mm)	OUTSIDE DIAMETER (mm) ISO STANDARD
80	6.0	98.0
100	6.1	118.0
150	6.3	170.0
200	6.4	222.0
250	6.8	274.0
300	7.2	326.0
350	7.7	378.0

400	8.1	429.0
450	8.6	480.0
500	9.0	532.0
600	9.9	635.0
700	10.8	738.0
800	11.7	842.0
900	12.6	945.0
1000	13.5	1048.0
1100	14.4	1152.0
1200	15.3	1255.0
1400	17.1	1462.0
1500	18.0	1565.0
1600	18.9	1668.0
1800	20.7	1875.0

(d) Fittings

Ductile iron fittings shall exhibit the following physical characteristics:

a. Minimum Tensile Strength : 392 N/mm^2

b. Minimum Elongation : 5%

Fittings shall have dimensions conforming to Table 20 to 33 and 41 to 46 of ISO 2531.

If fittings and special castings, specified herein are not covered in these specifications, the Contractor shall submit shop drawings or manufacturer's specifications to the Engineer for approval prior to casting.

(e) Coatings and Linings

(i) Coatings

All non-exposed pipes and fittings buried in the ground shall have a bituminous coating of either coal tar or asphaltic base with a minimum thickness of 0.1 mm. The finished coating shall be continuous, smooth, neither brittle when cold nor sticky when hot, and strongly adherent to the fittings.

All pipes and fittings which will be exposed to view in the finished work or to be in an intermittent or continuous submerged condition shall be painted on the exterior in accordance with the 1.10 PAINTING AND PROTECTIVE COATING unless otherwise noted.

(ii) Linings

All pipes shall have a cement mortar lining conforming to BS 4772 or manufacturer's standards approved by the Engineer. Minimum lining thickness shall be as specified in the following schedule:

SCHEDULE OF MINIMUM CEMENT MORTAR LINING THICKNESS FOR DUCTILE IRON PIPES

NOMINAL DIAMETER (mm)	LINING THICKNESS (mm)	TOLERANCES FOR PIPE END (mm)
250 and under	4	+2 to -1
300 to 600	6	+2 to -1
700 to 900	8	+2
1000 to 1200	10	+3
1400 and over	12	+4

Defective or damaged areas of lining shall be patched with stiff mortar in accordance with paragraph 4-7.2 of AWWA C104, or with epoxy resin filler or paste by cutting out the defective or damaged lining to the metal so that edges of the lining not removed are perpendicular or slightly undercut. Materials of epoxy resin filler or paste shall be approved by the Engineer before applied.

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

(f) Joints

(i) General

Pipe in size 250 mm and smaller shall be furnished with push-on joints or flanges. Pipe in sizes 300 mm and larger shall be furnished with mechanical joints or flanges. All joints shall be designed to have the same characteristics and strength as the connecting pipe.

(ii) Mechanical Joints

Mechanical joints shall conform to BS EN 598 or other internationally accepted standards or manufacturer's standards approved by the Engineer. The mechanical joint shall be designed to have a minimum effective depth of socket as stipulated in the following schedules.

SCHEDULE OF MINIMUM EFFECTIVE SOCKET DEPTH OF MECHANICAL JOINTS

NOMINAL DIAMTER (mm)	SOCKET DEPTH (mm)
250 and under	80.0
300 to 600	110.0

700 to 900	120.0
1000 to 1500	130.0
1600	160.0
1800	170.0

All ductile iron pipes and fittings of the mechanical joint type shall be provided with complete jointing materials unless otherwise specified. Gasket of the mechanical joint shall be styrene butadiene rubber (SBR) conforming to BS 2494.

Reclaimed rubber shall not be used. Gland and bolts and nuts shall be of spheroidal graphite iron castings conforming to BS EN 1563

(iii) Push-on Joints

Push-on joints shall conform to BS EN 598, or internationally accepted standards, or the manufacturer's standard approved by the Engineer. The push-on joint shall be designed to have a minimum effective depth of socket as stipulated in the following schedule:

SCHEDULE OF MINIMUM EFFECTIVE SOCKET DEPTH OF PUSH-ON JOINTS

NOMINAL DIAMETER (mm)	SOCKET DEPTH (mm)
80	76.5
100	80.3
150	86.8
200	93.7
250	96.3

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

Push-on joint pipe shall be furnished complete with gaskets and lubricant as recommended by the manufacturer. Gaskets shall be the same material specified for mechanical joints of the previous subsection.

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

(iv) Flanged Joints

All flanges shall be integrally cast with the pipe or fittings and shall have raised faces on the gasket surface.

Flange thicknesses shall conform to the following schedule:

SCHEDULE OF FLANGE THICKNESS
FOR DUCTILE IRON PIPES AND FITTINGS

NOMINAL DIAMTER (mm)	SOCKET DEPTH (mm)
80	16.0
100	16.0
150	16.0
200	17.0
250	19.0
300	20.5
350	22.5
400	24.0
450	26.0
500	27.5
600	31.0
700	34.5
800	38.0
900	41.5
1000	45.0
1100	48.5
1200	52.0
1400	55.0
1500	57.5
1600	60.0
1800	65.0

Notes: Flange thicknesses enumerated in the above schedule shall exclude the height of the raised face of the flange.

All ductile iron pipes and fittings of the flanged joint type shall be provided with complete jointing materials.

1.2.11 Steel Pipe

(a) General

All welding shall be in accordance with the SECTION 1.11.10(c) WELDING unless otherwise specified.

(b) References

The following standards are referred to:

BS 4622	Grey Iron Pipe Fittings
BS 1965	Carbon Steel Pipe Fittings
BS 4360	Rolled Steel for General Structure

BS 1387	Carbon Steel Pipes for Ordinary Piping
AWWA C200	Steel Water Pipe 6 Inches and Larger
AWWA C203	Coal-Tar Protective Coatings and Linings for Steel Water Pipelines Enamel and Tape - Hot Applied
AWWA C206	Field Welding of Steel Water Pipe Joints
AWWA C208	Dimensions for Steel Water Pipe Fittings
AWWA C210	Liquid Epoxy Coating System for the Interior and Exterior Steel Water Pipe
AWWA	Manual Steel Pipe Design and Installation M11
ASTM A283	Low and intermediate Tensile Strength Carbon Steel Plates of Structural Quality
ASTM A570	Hot-rolled Carbon Steel Sheet and Strip, Structural Quality
ISO 7/1	Pipe threads where pressure-tight joints are made on the threads
ISO 1459	Metallic Coating-Protection against Corrosion by Hot Dip Galvanizing- Guiding Principles
ISO 1461	Metallic Coating-Hot Dip Galvanized Coating on Fabricated Ferrous Products-Requirements

(c) Pipes

(i) Materials and Fabrication

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

Steel sheets or plates shall have a minimum yield point not less than 226N/mm^2 and shall conform to the following materials.

a. BS 4360
b. BS 1387
d. ASTM A283 Grade D
e. ASTM A570 Grade 33

Fabrication of steel pipe shall be in accordance with BS 1387 or AWWA 200. The weld shall be of reasonably uniform width and height for the entire length of the pipe and shall be made by automatic means except that with approval of the Engineer, manual welding by a qualified procedure and welder may be used.

All longitudinal seams or spiral seams and shop girth seams of pipe shall be butt welded. The maximum allowable number of shop seams shall be one longitudinal seam and three girth seams per length of pipe. The longitudinal seams shall be staggered on opposite sides for adjacent section. No reinforcing ring, plate or saddle shall be provided on the exterior or interior of pipe. The length of pipe shall be six (6) meters or smaller unless otherwise specified.

(ii) Pipe Dimensions

The nominal pipe diameters shall be of the following outside diameters and wall thickness before lining and coating.

OUTSIDE DIAMETER AND WALL THICKNESS OF STEEL PIPE

NOMINAL DIAMETER (mm)	OUTSIDE DIAMETER (mm)	MINIMUM WALL THICKNESS (mm)
15	21.7	2.8
20	27.2	2.8
25	4.0	3.2
32	42.7	3.5
40	48.6	3.5
50	60.5	3.8
65	76.3	4.2
80	89.1	4.2
100	114.3	4.5
125	139.8	4.5
150	165.2	5.0
200	219.1	5.8
250	273.0	6.6
300	323.9	6.9
350	355.6	6.0
400	406.4	6.0
450	457.2	6.0
500	508.0	6.0
600	609.6	6.0
700	711.2	7.0
800	812.8	8.0
900	914.4	8.0
1000	1016.0	9.0
1100	1117.6	10.0
1200	1219.2	11.0
1400	1420.0	13.0
1500	1524.0	14.0
1600	1620.0	15.0
1800	1820.0	16.0

(d) Fittings

Fittings shall be shop fabricated and shall be designed to have the same strength as piping. Reinforcing rings or saddles shall be provided where required in accordance with AWWA Manual M11.

Dimensions of fittings shall conform to the followings:

AWWA C208
(Table 1 and Fig.1 and
Tables 2A to 2B and Fig.2)

Bends having a deflection angle of 22.5 degrees and smaller shall be two-piece bends. Bends having a deflection angle of over 22.5 degrees and up to 45 degrees shall be fabricated using three pieces. Bends having a deflection angle of over 45 degrees shall be four-piece bends.

(e) Coatings and Linings

(i) Exterior Protection

All pipes and fittings which will be exposed to view in the finished work, or be in intermittent or continuous under water shall be painted in accordance to the specification detailed in SECTION 1.10 PAINTING AND PROTECTIVE COATING otherwise noted.

The outside of piping which will be below ground shall have a coal tar enamel and bonded double asbestos felt wrap as specified in Appendix A, Sec.A1.2 of AWWA C203. The primer and coal tar enamel shall be as follows:

Primer:	Type B conforming to Sec. A.2.4 of AWWA C203
Coal tar enamel:	Type I conforming to Sec. A.2.5 Table 1 of AWWA C203

The construction of exterior protection described above shall be as follows:

a. Primer, Type B specified above;
b. Coal tar enamel, Type I specified above, dry film thickness 2.4 mm ñ 0.8 mm;
c. Bonded asbestos felt;
d. Coal tar enamel, Type I same as the above, dry film thickness 0.8 mm minimum;
e. Bonded asbestos felt; and
f. One coat of water-resistant whitewash.

(ii) Linings

Unless specifically noted otherwise, all steel pipe and fitting shall be epoxy or coal tar epoxy lined on the inside in accordance with AWWA C210.

The lining systems such as epoxy or coal tar epoxy shall be shop applicated. They shall consist of the following:

Epoxy System

a. One (1) coat of liquid two-part chemically cured rust-inhibitive epoxy primer
b. One (1) or more coats of a liquid two-part epoxy finish coat which contains no coal tar

Coal Tar Epoxy system

a. One (1) coat of liquid two-part chemically cured rust-inhibitive epoxy primer
b. Two (2) coats of a two-part coal-tar epoxy finish coat

Primer and finish coat(s) shall be from the same manufacturer.

The epoxy lining system may alternatively consist of two or more coats of the same epoxy coating without the use of a separate primer. This alternative system shall conform to requirements of AWWA C210 and the first coat of this alternative system shall be considered as the primer.

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

(iii) Coatings and Linings at Pipe Ends

Beveled Ends

At beveled ends of pipe and fittings 700 mm and larger in diameter, both shop lining and coating shall have a cutback of 20 centimeters to facilitate field welding.

At beveled ends of pipe and fittings 600 mm and smaller in diameter, only the coating shall have a cutback of 20 centimeters, and lining shall be extended to the pipe ends to facilitate field welding.

All interior and exterior surfaces left as cutback at beveled ends shall be given one (1) shop coat specified in the previous sections of (e), i) Exterior Protections and (e), ii) Linings.

After field welding, the interior surface left as cutback shall be lined with epoxy system or coal tar epoxy system specified in the previous section (e), ii) Linings and the exterior surface left as cutback shall have a heat-shrinkable corrosion protection sleeve which will be specified hereinafter.

Plain-Ends and Shouldered-Ends

At all plain-ends and shouldered-ends below ground specially prepared for sleeve couplings and other flexible or expansion joints, only the coating except primer shall have a cutback of required length for replacing the coupling or joint. The exterior area which may contact with handling liquid shall have the same coating as the pipe lining specified after removing the said primer completely. After setting couplings or joints, the remaining area which has only the said primer and the exterior of couplings or joints shall be finished with petrolatum corrosion protective tape which will be specified hereinafter. The lining shall be extended to the pipe ends.

At all plain-ends and shouldered-ends above ground specially prepared for couplings and joints, the exterior area which may contact with the handling liquid shall have the same coating as the pipe lining specified after removing primer shop applied completely. After setting couplings and joints, the remaining area and the exterior of coupling or joints shall be painted in accordance to the specification detailed in section 1.10 PAINTING AND PROTECTIVE COATING unless otherwise noted. The lining shall be extended to the pipe ends.

Flanged Ends

At all flanged ends, no cutback of lining and coating shall be provided. The entire surface of the flange shall be painted with the epoxy system or coal tar epoxy system specified in the previous Section (e), ii) Linings.

(iv) Galvanized

Galvanized coating on the inside and outside of pipe with zinc shall conform to ISO 1459 and ISO 1461.

Thickness of galvanized coating shall be not less than 550 g/m^2.

Field cutting with flame and field welding of galvanized steel pipe will not be permitted.

(f) Joints

(i) General

Piping shall be furnished with standard flanged, welded or threaded joints.as required by the specifications. All joints shall be designed to have the same characteristics and strength as the connecting pipe.

Pipe and fittings for use with sleeve couplings, transition couplings, or expansion joints shall have plain ends.

Pipe in sizes 300 mm and smaller for use with Victaulic couplings shall have either a grooved end or a shouldered end. Pipes in size 350 mm and larger for use with the victaulic coupling shall have a shouldered end.

(ii) Flanged Joints

Flanges shall be made as seamless forgings or cut and fabricated from steel plate. Flanges shall be designed for the designed maximum working pressure, unless otherwise specified.

Flanges shall be raised face neck flange which shall be made as seamless forgings or cut and fabricated from steel plate, and shall be attached to pipe or fittings by means of single butt-weld. Steel plate flanges having either a raised or flat face may be allowed to be used for pipes or fittings of 300 mm and smaller in diameter. Steel plate flanges shall be attached to pipes or fittings by means of two (2) fillet joints.

Flange dimensions other than specified in Section 1.2.9 FLANGE SCHEDULE shall conform to ISO, JIS, ANSI, DIN or BS or internationally accepted standards.

(iii) Welded Joints

Welded joints shall conform to the requirements of AWWA C206 and have beveled pipe ends.

Unless otherwise specified, field-welded joints shall be butt-welded joints.

Ends for field welding pipes in sizes 600 mm and under shall be beveled to permit "single-welded butt joints" from the outside of the pipe. Ends for field welding pipes

in sizes 700 mm and over with a wall thickness of 15 mm and thinner shall be beveled to permit "single-welded but joints" from inside of the pipe.

Ends for field welding pipes in size 700 mm and over with wall thickness of 16 mm and thicker shall be beveled to permit "double welded butt joints" form both side, outside and inside of the pipe.

(iv) Screw Joints

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

1.2.12 Flexible Joints and Couplings

(a) General

All flexible joints and couplings shall be designed for a minimum working pressure of 0.98 MPa unless otherwise specified and to the maximum designed working pressure.

(b) References

The following standards are referred to:

BS 4360	Rolled Steel for General Structure.
BS EN 1563	Spheroidal Graphite Iron Castings.
BS EN 1562	Blackheart Malleable Iron Castings.
BS 2494	Elastomeric seals for joints in pipe work

(c) Mechanical Flexible Joints

(i) General

Mechanical flexible joints shall be closer joint, CL-A type and designed to withstand any forces or any combination of forces due to expansion and contraction, shear deflection, distortion and other forces to the pipeline.

(ii) Design Requirements

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

(a) Two (2) meters depth of earth cover the unit weight of which is 2.0 ton/m^3 plus a 20 ton truck loading.

(b) Minimum shear deflection of 100 mm.

(c) Other requirements as shown below.

NOMINAL DIAMETER (mm)	MAXIMUM LAYING LENGTH (mm)	MINIMUM ALLOWABLE EXPANSION (mm)	MINIMUM ALLOWABLE CONTRACTION (mm)
300 to 400	1600	230	80
450	1600	240	80
500 & 600	1700	270	80
700	1800	270	90
800 & 900	1800	310	110
1000	1900	300	130
1100	1900	300	140
1200	1900	300	150
1400	1900	300	170
1500	2000	350	200
1600	2000	350	220
1800	2000	370	220

(iii) Construction and Materials

Mechanical flexible joints shall consist of slip pipes, a sleeve pipe, two (2) rubber rings and housings and others, and shall have flanges at both ends. Each slip pipe shall have the continuous ring type reinforcing rib and flanged end. Slip pipes and sleeve pipes shall be fabricated from steel sheets or plates, having a minimum yield point of 216 N/mm^2, conforming to BS 4360, or equivalent.

Rubber ring housing shall be made of ductile iron casting conforming to BS EN 1563, BS EN 1562, or equivalent. Rubber ring shall be U-type, automatic seal mechanism using internal pressure of flexible joint and styrene butadiene rubber (SBR) conforming to BS 2494. Reclaimed rubber shall not be used.

(iv) Coatings and Linings

All exterior surfaces of mechanical flexible joints shall, unless otherwise specified, be painted in accordance to the specification detailed in SECTION 1.10 PAINTING AND PROTECTIVE COATING.

All interior surfaces of mechanical flexible joints and surfaces of slip pipes where they may contact with handling liquid shall be lined with an epoxy system or coal tar epoxy system as specified in Section 1.2.11 (e), ii) Linings of unless specifically noted.

(d) Sleeve Couplings

(i) General

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

(ii) Construction and Materials

Middle ring shall be of sizes to fit the pipes and fittings furnished. Middle ring and follower in sizes 300 mm and smaller shall be of steel sheets or plates conforming to BS 4360 Hot – Rolled section & plate. Those in sizes 350 mm and larger shall be of steel sheets or plates as specified above. Bolts and nuts for assemblage of coupling shall be of steel as specified above.

Gaskets shall be styrene butadiene rubber (SBR) conforming to BS 2494. Reclaimed rubber shall not be used. Bolts and nuts for the coupling shall be of the same materials as the sleeve as specified above. Length and minimum thickness of the middle ring shall conform to the following requirements.

NOMINAL DIAMETER (mm)	**MINIMUM LENGTH MIDDLE RING (mm)**	**MINIMUM THICKNESS MIDDLE RING (mm)**
150	100	7.9 (9.5)
200	100	7.9 (11.5)
250	178	9.5 (11.5)
300	178	9.5 (11.5)
350 to 800	178	8
900	178	8
1000 & 1100	200	12.5
1200 & 1400	250	125
1500	250	12.5
1600 to 1800	250	12.5

Note : ( ) for iron casting middle ring

(iii) Joint Harnesses

Joint harnesses shall consist of stud bolts, and gusset plate with back and front plate or ring. They shall be of steel conforming to BS 4360 or better. Joint harnesses shall be shop fabricated and welded on pipes or fittings and field welding of joint harnesses will not be permitted unless otherwise specified.

(iv) Coatings and Linings

All exterior surfaces of middle ring and followers with bolts shall, unless otherwise specified, be painted according to the specification detailed in section 1.10 PAINTING AND PROTECTIVE COATING.

All interior surfaces of middle ring shall be lined with epoxy system or coal tar epoxy system specified in Sub-section 1.2.11 (e), ii) Linings unless specifically noted.

(e) Victaulic Couplings

Victaulic couplings shall be malleable iron casting conforming to BS EN 1562 or ductile iron casting conforming to BS EN 1563 and shall be designed to providing a manual connection by engaging the coupling shoulders on pipe ends which have been grooved or banded and machined to fit the coupling dimension. The coupling shall enclose a sealing gasket which will provide a water tight connection and allow for expansion and contraction of the joint and reasonable deflection. Two or more bolts shall be used to assemble the coupling.

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

Gasket shall be styrene butadiene rubber (SBR) conforming to BS 2494. Reclaimed rubber shall not be used. Bolts and nuts for assemblage of coupling shall be BS 4395 unless otherwise specified.

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

(f) Flange Adapter

(i) Construction and Materials

Materials of major parts of flange adapter such as flanged spigot pipe, ring stopper, follower, stud bolts and bolts and nuts for assemblage of flange adapter shall be steel having minimum yield point of 226 N/mm^2.

Gasket and O-ring shall be styrene butadiene rubber (SBR) conforming to BS 2494.Reclaimed rubber shall not be used.

(ii) Coatings and Linings

All exterior surfaces of flanged spigot pipe and follower with bolts shall, unless otherwise specified, be painted in accordance to the specification detailed in section 1.10 PAINTING AND PROTECTIVE COATING.

All interior surfaces of flanged spigot pipe shall be lined with epoxy system or coal tar epoxy system specified in Sub-section 1.2.11(e), ii) Linings unless specifically noted.

1.2.13 Joint Coats and Petrolatum Corrosion Protection Tape

(a) General

Joint coats shall be heat-shrinkable sleeve and applied for corrosion protection of all field welded steel pipe joints buried under the ground unless otherwise specified.

Petrolatum corrosion protection tape shall be applied for valves, flexible joints, couplings and all other ferrous materials which will be laid under ground as specified.

(b) References

The following standards are referred to:

BS 3416 Petroleum Asphalts
BS 2000 - 132 Lubricating Grease

(c) Heat-Shrinkable Sleeve

Heat-shrinkable sleeve shall consist of outer and inner layers. The outer layer shall be cross linked polyethylene and the inner layer shall be butyl rubber based adhesive.

Length of sleeve shall be not less than 600 mm and minimum thickness of outer layer and inner layer before shrinkage shall be as follows:

APPLICABLE DIAMETER (mm)	MINIMUM THICKNESS OF OUTER LAYER (mm)	MINIMUM THICKNESS OF INNER LAYER (mm)
350 and smaller	0.6	0.6
400	0.9	0.6
450	1.2	0.6
500 and larger	1.5	0.6

Physical properties of outer and inner layers shall be as follows:

Physical Properties of Outer Layer

Specific Gravity (Min.) : 0.91
Tensile Strength
Circumferential (Min., kg/cm2) : 180
Axial (Min., kg/cm2) : 150
Elongation
Circumferential (Min., %) : 250
Axial (Min., %) : 500
Identification Hardness (Min., Shore D) : 43
Dielectric Strength (Min, kV/mm) : 30
Volume Resistivity (Min, cm) : 1x10
Shrinkage
Circumferential (Min., %) : 40
Axial (Max., %) : 8

Physical Properties of Inner Layer

Specific Gravity (Min.) : 1.0
Consistency (Max.) : 80
Softening Point (Min. degrees C) : 60
Penetration (Max.) : 90

(d) Petrolatum Corrosion Protection Tape

Petrolatum corrosion protection type shall be Denso tape corrosion protection tape and shall be made of saturated unwoven cloth of synthetic fiber impregnated with the petrolatum compounds which consist of petrolatum, inactive inorganic and organic fillers, and organic preservative. It shall be designed to have high and long life corrosion protection with providing self-bounding, adhesivity, electric insulation, water insulation, weather resistance, chemical resistance, anti-micro organism, etc.

After the petrolatum corrosion protection tape has been applied, its surface shall be protected with wrapping tape unless otherwise noted. The wrapping tape shall be self adhesive PVC, Polyethylene or other materials approved by the Engineer. The wrapping tape shall be a product of the same manufacturer with that of the petrolatum corrosion protection tape.

1.2.14 Pipe Hangers and Supports

(a) General

Hangers and supports shall be of approved standard design where possible and shall be adequate to maintain the supported load in proper position under all operating conditions.

The minimum working factor of safety for pipe supports shall be 5 based on the ultimate tensile strength of the material assuming pipe between supports to be filled with water.

Pipe hangers and supports shall be designed based on pipe weight including water and maximum support spacing which are tabulated in the following table.

NOMINAL PIPE DIAMETER	**PIPE WEIGHT PER 1 METER**	**MAXIMUM SUPPORT SPACING**		
		STEEL PIPE	**DUCTILE CAST IRON OR CAST IRON PIPE**	**PVC PIPE**
(mm)	**(kg)**	**(m)**	**(m)**	**(m)**
40 & smaller	10	2.0	1.5	1.0
50	15	2.0	1.5	1.0
65	20	2.0	1.5	1.5
80	25	2.0	1.5	1.5
100	40	4.0	1.5	1.5
125	50	4.0	1.5	2.0
150	65	4.0	1.5	2.0
200	110	4.0	1.5	2.0
250	150	4.0	1.5	2.0
300	200	4.0	1.5	2.0

(b) Materials

All overhead hangers shall be provided with turnbuckles and supported by threaded hanger rods from inserts in the concrete. Overhead hangers, turnbuckles hanger rods and inserts shall be galvanized steel conforming to BS 4360 unless otherwise specified. Hanger rods shall be machine threaded and rod sizes shall conform to the following Table.

PIPE DIAMETER (mm)	HANGER ROD DIAMETER (mm)
80 and smaller	10
100 to 150	12
200 and 250	16
300	19

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

PIPE DIAMETER (mm)	U-BOLT DIAMETER (mm)
80 and smaller	10
100 to 125	12
150 and 300	16

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

Threads for all nuts, bolts and rods shall conform to ISO 68 "ISO General Purpose Screw Threads - Basic Profile".

1.2.15 Pipe Installation

(a) General

This section covers the installation of all pipe and fittings except all pipe and fittings in the ground.

The installation of underground piping is specified in SECTION 1.10.4.

Piping shall be installed to the required lines and grades and as closely as possible to walls, ceilings, columns and other structural parts so as to occupy the minimum of space, and all offsets and fittings required to accomplish this must be furnished. All dimensioned pipes and fittings shall be installed before fitting make up pieces, and the whole shall be joined so that no stress or strain is created in the lines and associated equipment due to forcing parts into position.

When installation is not in progress, including lunchtime, the open ends of the pipe shall be closed by a watertight plug or other approved means. Flotation of pipe shall be prevented. Good alignment shall be preserved during installation. In the event interference develops between piping and other appurtenances the Engineer will decide which work is to be relocated regardless of which was first installed.

Changes in direction shall be made using proper fittings. Piping shall run parallel and at right angles to walls, unless noted otherwise.

Temporary bracing and supports shall be provided to adequately support the pipe during its installation and care shall be taken in placing piping to prevent damage to the pipe lining or pipe coating or to adjacent structures or equipment. Supporting piers and blocking shall be in place before temporary supports and bracing are removed.

All piping shall have a sufficient number of flanged joints to allow convenient removal of piping. Threaded piping shall have a sufficient number of unions to allow convenient removal of piping.

Systems shall be arranged with low points and drains to permit complete drainage of the system. Fill connections for the purpose of testing shall also be provided on closed system when required.

Adequate air vents shall be provided at high points in all liquid carrying pipes. Interior piping shall be rigidly supported as specified in SECTION 1.2.14 “PIPE HANGERS AND SUPPORTS".

Upon completion of installation and testing, the Contractor shall paint all exterior piping in accordance to the specification detailed in SECTION 1.10 PAINTING AND PROTECTIVE COATING.

(b) References

The following standards are referred to:

AWWA C111	Rubber-gasket joints for ductile-iron and grey-iron pressure pipe and fittings
AWWA C600	Installation of grey and ductile cast-iron water mains and appurtenances
AWWA C603	Installation of asbestos-cement pressure pipe
AWWA C900	Polyvinyl Chloride (PVC) pressure pipe, 4-inches through 12 inches, for water
AWWA C901	Polyethylene (PE) pressure pipe, tubing and fittings, 1/2 inches through 3 inches, for water
AWWA MANUAL	
M11	Steel pipe design and installation
M23	PVC Pipe Design and Installation
ISO 4482	Asbestos-cement pipelines - guide for laying

(c) Ductile Iron and Cast Iron Pipe

(i) General

All work shall be in full conformance with the manufacturer's recommendations and the requirements of AWWA C600 except as otherwise provided herein.

The lining and coating shall be protected at all times. All repairs shall be the responsibility of the Contractor.

(ii) Mechanical Joints

Mechanical joints at fittings and pipe shall be installed in accordance with the "Notes on Installation of Mechanical Joints under AWWA C111" and the instructions of the manufacturer. To assemble the joints in the field, the Contractor shall thoroughly clean the joint surfaces and rubber gasket with soapy water before inserting the spigot into the bell of the joint. Bolts shall be tightened alternately on opposite ends of joint diameters and in rotation around the pipe. When properly assembled, the gland shall be equidistant from the bell face at all points. All nuts shall be tightened with use of torque wrenches finally and confirm all nuts are tightened at the designated torque. The bolting torque for each size of bolt shall be in accordance with the manufacturer's standard but in general they are as follows:

BOLT SIZE (mm)	**STANDARD TORQUE (N-m)**
16	58.8
20	98.0
24	137.2
30	196.0

If effective sealing is not attained at the torque indicated above, the joint shall be disassembled, cleaned and reassembled. No overstressing of the bolts shall be allowed.

When it is desirable to deflect mechanical joint pipe in order to form a long-radius curve, the amount of deflection shall be in accordance with the instructions of the manufacturer and as directed by the Engineer.

(iii) Push-on Joints

The method of jointing push-on joint pipe shall be in strict accordance with the manufacturer's instructions. Pipe shall be laid with bell ends looking ahead. A rubber gasket shall be installed in the groove of the bell end of the pipe, and the joint surface cleaned and lubricated. The plain end of the pipe to be entered shall then be inserted in alignment with the bell of the pipe to which it is to be joined, and pushed home with a jack or by other means.

Pipe that is not furnished with a depth mark shall be marked before assembly to assure that the pipe end is inserted to the full depth of the joint. Field cut ends of pipe shall be filed or ground exactly the same as the pipe end manufactured at the factory.

When it is desired to deflect push-on joint pipe in order to form a long-radius curve, the amount of deflection shall be as directed by the Engineer and the manufacturer's instructions shall be observed.

The deflection of pipes shall be given only after complete jointing of the pipes which shall keep the pipes in a straight line.

(iv) Flanged Joints

After cleaning all flanged surfaces, jointing materials shall be tightened with a suitable wrench to the proper torque.

Nuts spaced at an angle of 180 degrees apart shall be tightened alternately in order to produce an equal stress on the entire surface of the flange.

All bolts and nuts for flanged-joints shall be well smeared with grease.

All nuts shall be confirmed to be tightened at the designated torque as shown below using torque wrench.

BOLT SIZE (mm)	**STANDARD TORQUE (N-m)**
16	58.8
20	88.2
24 and 27	176.4
30	323.4
33	323.4
36 and 39	490.0
45	568.4

(d) Steel Pipe

(i) General

Steel pipe shall be installed in accordance with AWWA M11.

All work shall be in full conformance with the manufacturer's recommendations.

The lining and coating shall be protected at all times. All repairs shall be the responsibility of the Contractor.

Where steel pipe passes through wall sleeves, the sleeves shall be caulked with sealing compounds recommended by the pipe manufacturer and approved by the Engineer.

(ii) Flanged Joints

Same as previous Section (c), iv) Flanged Joints.

(iii) Screwed Joints

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

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

No close right and left hand nipples shall be used. All nipples shall be of such length that the correct size of pipe wrench can be used on them when in place.

(iv) Welded Joints

Welding shall be in accordance with the SECTION 1.11.10 (c) WELDING.

(v) Flexible Joints

During transportation, handling, storing and installation, any deflection, contraction, expansion or any other transformation of the flexible joints shall be avoided. Extreme care must be made to prevent any scarring or nickling of the joints from bearing on sharp objects.

All flexible joints shall be installed true to the lines and levels and the Contractor shall maintain the joints in the same condition as shipped from the manufacturer. Disassembling the joints at the site shall be avoided unless otherwise directed by the Engineer. The Contractor shall not remove any protective ribs, shipping protection or other devices provided to the joints before jointing work is completed.

(vi) Sleeve Couplings

For jointing sleeve couplings, the Contractor shall take account of the manufacturer's instructions and recommendations as to the methods and equipment to be used in assembling the joint.

In particular the Contractor shall render the end of each pipe perfectly smooth so as to allow the middle ring to slide freely and where necessary the pipe ends shall be recoated with the epoxy system or coal tar epoxy paint system as specified in SECTION 1.2.10 (e) ii) Linings.

(vii) Victaulic Couplings

The method of assembling and jointing victaulic couplings shall be in accordance with the manufacturer's instructions and recommendations.

Before setting a sealing gasket, pipe ends either grooved or shouldered shall be cleaned. Sealing surfaces of pipe ends and sealing gasket shall be lubricated with the special jointing lubricant supplied by the coupling manufacturer or a good quality vegetable based lubricant.

After setting a sealing gasket, the Contractor shall set the housing properly and nuts shall be tighten equally.

1.2.16 Plastic Material Pipes

Plastic material pipes such as polyvinyl chloride pipe and polyethylene pipe shall be installed in accordance with AWWA C900, C901 and AWWA MANUAL M23.

All work shall be done in accordance with the manufacturer's recommendations, printed technical data and instructions.

Careful consideration must be given to the handling and storing of plastic material pipes. The pipe must be stored out of any direct sunlight. Extreme care must be made to prevent any scarring or nicking of the pipe from bearing on sharp objects. Any pipe which has any cut or bruise deeper than 10% of the wall thickness will be rejected and shall not be used in the work. The section of pipe with such a cut shall be rejected in its entirety. The pipe shall be stored in such a manner that no direct sunlight is on the pipe but ventilation is provided. Covering the pipe with a tarpaulin shall not be allowed. Stacking shall not exceed 60 centimeters in height.

Joints for PVC pipe shall be solvent welded or coupling type except flanged or threaded, where required. In making solvent welded connections, the Contractor shall clean dirt and moisture from the pipe and fittings. Care shall be taken in order that the solvent cement will not be spilled on valves or allowed to run from joints. When cuts are necessary they shall be perpendicular to the axis of the pipe and smooth.

Where plastic material pipes pass through wall sleeves, the sleeves shall be caulked with sealing compounds recommended by the pipe manufacturer and approved by the Engineer. Sealing compounds shall be applied in accordance with the manufacturer's instructions.

1.2.17 Joint Coats

All installation work of joint coats shall be in full conformance with the manufacturer's recommendations, printed technical data and instructions.

Careful consideration must be given to handling and storing joint coats. The joint coats must be stored out of any direct sunlight and packaging furnished shall not be opened before use at site. Extreme care must be made to prevent any scarring or nicking of the joint coats from bearing on sharp objects and to keep joint coats from heat.

1.2.18 Petrolatum Corrosion Protection Tape

All installation work of petrolatum corrosion protection tape shall be in full conformance with the manufacturer's recommendations, printed technical data and instructions.

Surface to be coated with petrolatum corrosion protection tape shall be cleaned. Burrs, rust, dirt and dust, water, oil and grease shall be removed completely from the surface to be applied.

After complete cleaning of the surface, the surface shall be covered with paste. Concave and convex parts shall be filled with filler and made to be a smooth and even surface. The said paste and filler shall be the product supplied by the manufacturer of the petrolatum corrosion protection tape.

The petrolatum corrosion protection tape shall be lapped by adding proper tension to a slightly stretched the tape. At least 150 mm overlapping of the tape shall be given. After lapping the tape, the tape surface shall be pressed by the hands in order to bond it firmly.

After the petrolatum corrosion protection tape is applied, its surface shall be protected with wrapping tape as specified unless otherwise noted.

1.2.19 Pipeline Identification

Pipework shall be colour coded as defined in Clause 1.1.1.18.

To assist in process tracing direction of flow, arrows shall be applied using adhesive tape. Where pipelines are lagged tape shall be applied to both the external lagging and the pipe.

1.3 Centrifugal Pump Sets

1.3.1 References

The following standards are referred to.

BS EN ISO 14691	Flexible Couplings
ISO 3555 Class B	Testing Methods for Centrifugal Pumps, Mixed Flow Pumps and Axial Flow Pumps
BS 1452	Gray Iron Casting
ASTM B 584	Bronze Castings
ISO 3555	Centrifugal mixed flow and axial pumps-Code for acceptance test - Class B.
BS 292	Ball Bearings
ISO 3555 Class B	Testing Methods for Centrifugal Pumps, Mixed Flow Pumps and Axial Flow Pumps
ISO 2858	End Suction Centrifugal Pumps
ASTM B 584	Bronze Castings
BS 1452	Gray Iron Castings
ISO 2858	End-suction centrifugal pumps (rating 16 bar) - Designation, nominal duty point and dimensions
ISO 3069	End-suction centrifugal pumps - Dimensions of cavities for mechanical seals and for soft packing

1.3.2 Pump Performance

The pump head versus flow characteristic shall be stable, rise continually to close valve head and be non-overloading.

The closed valve head shall be a minimum of 110% of the duty head.

Contactors shall select the most economic pumps given the constraints of the operating parameters, as operating costs will be considered in association with the capital costs in the tender evaluation.

Characteristic and system curves for the pumps against the various static heads shall be supplied with the bid. When tested through their complete range of workable heads at the manufacturer's works the pumps shall give results which conform to the stated duty points. The curves shall be presented at a reasonably large scale and shall also show pump efficiency and kW loading.

Where pumps are working in multiple parallel operations they shall operate satisfactorily on the system curve regardless of the number of pump sets running and not approach run out condition.

The system design and pump curves shall illustrate the design conditions with operational efficiencies and power demands illustrated on the systems curve or envelopes and shall take account of at least the following conditions

(i) the full range of static heads occurring in the works
(ii) the various possible combinations of parallel pump operation

The net positive suction head required (NPSHR) curve for the full range of operation shall be submitted and shall be compatible with the available to enable the pump to operate, without cavitations over the full range of flows at all liquid levels.

Pump motors shall be rated a minimum of 10% higher than the maximum power required by the pump across the whole of its operating duty.

Where pump sets are fitted with flywheels for surge control reasons, the pumps motors and associated starters shall be suitably sized to cater for the increased starting torque requirements.

Contractors shall provide with the bids, sales brochures for the plant offered and shall include technical details of materials of construction, thrust bearings, lubrication and sealing.

1.3.3 Materials and Workmanship

(a) General

All materials shall be of the highest grade, free from defects and imperfections, of recent manufacture and unused, and of the classification and grades designated. Material not specifically described shall conform to the manufacturer's standard for the applicable part in the service intended.

All materials, supplies, and articles, not manufactured by the Contractor, shall be the products of recognized reputable manufacturers. The products of firms other than those specified herein will be accepted when it is proved to the satisfaction of the

Engineer that they are equal in strength, durability, usefulness, and convenience for the purpose intended.

The Contractor shall furnish to the Engineer for his approval the names of the manufacturers of all machinery and other equipment which he contemplates incorporating in the work, together with performance capacities and other relevant information pertaining to the equipment. Samples of materials shall be submitted for approval when so directed. Equipment, materials, and articles installed or used without such approval shall be at the risk of subsequent rejection.

All wearing or erodible materials associated with water pumps shall be compatible with potable water and not impart taste, odour, colour or toxicity. Internal coatings shall be approved for use with potable water and external coatings if not specified shall be capable of withstanding continuous severe condensation. The paint manufacturer shall confirm and guarantee the suitability of his product for the working environment.

Workmanship shall be of the highest grade and in accordance with the best modern standard practice.

Liberal factors of safety shall be used throughout the design and especially in the design of all parts subject to alternating stresses or shock. For pumps, the maximum units stress due to maximum operating conditions shall not exceed the values given in the following table, with the exception of the pump shaft in which the combined torsional and axial stress shall not exceed seven (7) percent of the tensile strength of the material.

Table of Unit Stress (N/mm^2)

	Stress in Tension	Stress in Compression
Cast Iron	14.7	73.5
Plate Steel	88.2	88.2

For other materials used in the construction of the pump, the maximum stressed in tension or compression due to the most severe operating conditions shall not exceed one-third of the yield point or one-fifth of the tensile strength of the material. The maximum unit working stresses in shear shall not exceed 14.7 N/mm^2 in cast iron, nor more than 60 percent of the allowable stresses in tension for other materials.

(b) Pump Casing

The pump casing shall be high grade cast iron to BS 1452 or equivalent and be abrasive resistant, capable of taking shock loads and incorporate lifting eyes located for removal of the pump. Lifting eyes shall be collared, certified, tested and marked individually with identity number and Safe Work Load. Test certificates shall be provided. Suction and delivery branches shall be incorporated in the casing and include tappings for pressure gauges. Drain plugs shall be provided at the lowest point of the casing and automatic air release valves complete with isolating cocks and bleed lines, to the bedplate tundish, shall be provided on each stage of the pump. Flanges shall comply with BS 4772, ISO 2531 or equivalent and be drilled to

suit the adjacent pipework. A suitably rated pressure gauge shall be provided with each pump set. The gauges shall be suitably damped internally to prevent damage through system pressure surges.

Pump casings and discharge pipework up to and including the isolation valves and non- return valves, shall be rated for the maximum closed valve head developed; including the maximum suction pressure, or 16 bar, whichever is the greater.

(c) Impeller

Impellers on potable water applications shall be high grade bronze. On raw water applications the impeller shall be stainless steel.

The impeller(s) shall be keyed and positively secured to the pump shaft and shall be designed so that there is no tendency for any parts to unlock due to reverse rotation of the pump.

Hydraulic balancing holes in the impeller will only be accepted on end suction overhung impeller water pumps and where the impeller is suitably reinforced to minimize stress concentrations.

(d) Casing Wear Rings

Removable wearing rings shall be provided on the pump casing. Casing wear rings shall be locked to prevent rotation by dowel or similar approved method. Ease of replacement shall be a major design criterion. The wear rings shall be of bronze casting conforming to ASTM B 584 or better and designed such that hydraulic pressure aids the sealing of the ring into the pump casing. Casing wear rings shall be incorporated on all rotating/stationary interfaces.

(e) Bearings

(i) Thrust Bearing

The axial thrust generated shall be taken by an appropriate thrust bearing arrangement. Thrust bearing arrangements incorporated into the motor housing are not permitted. Setting of thrust bearings shall account for dynamic loading.

(ii) Rolling Element Bearing

Ball or roller bearings shall comply with BS 292 or equivalent and shall be sealed for life. They shall be rated to give a minimum life of 70,000 hours at maximum load without replacement. Bearings shall be protected by water throwers and lip seals.

(iii) Submersible Bearings

Submersible bearings shall be of the water lubricated type with corrosion resisting outer shell and internal lining of high resilience and abrasive resisting properties. The shaft should be protected locally with shaft sleeves to ensure that particles in suspension in the water do not cause premature wear.

Intermediate support bearings shall be housed in a spider arrangement spigot to the discharge column flanges to ensure concentricity. The upper water lubricated

bearings shall be maintained in a lubricated condition particularly on pump start up, in order to avoid dry running of the bearing.

(iv) Plain/Bush Bearings

Bush bearings, where utilized, shall be in bronze or equal, split for easy maintenance and positively locked to prevent rotation.

(f) Sealing

(i) General

The means of sealing shall be soft packed gland.

(ii) Soft-Packed Gland

Gland packing shall be graphite impregnated Polytetraflouroethylene (PTFE), of approved manufacturer. Asbestos based packing will not be permitted.

The gland design shall incorporate the following:

- A tapered "lead in" at the mouth of the gland entry to facilitate packing replacement and obviate the risk of damage on assembly.
- The surface finish of the adjacent metal parts shall be O.4μm CLA on the shaft gland sleeve and 1μm CLA on the stuffing box bore.
- Where running clearances are excessive, the packing shall be protected by an independent ring of suitably robust material which reduces the clearance to a minimum.
- The packing must not be used as a bearing.
- All studs, dowels and adjustable nuts shall be manufactured from stainless steel,
- Lantern rings shall be of gun metal or bronze and shall be split for ease of' removal.
- Pumped water supplies to the lantern ring shall be free from abrasive solids.

(iii) Seal/Gland Drainage

Seal/gland drainage shall be collected in a collecting tray formed integrally with the pump casing stuffing box. The tray shall not extend high enough to submerge the gland in the event of drain hole blockages. Drainage shall be piped to the bed plate tundish located at the non-driven end of the pump.

(g) Pump Shaft

(i) Shaft Sleeves

Where shafts are exposed to the process fluid and where they pass through the sealing gland they shall be fitted with sleeves of bronze or stainless steel, positive driven and which extend through the stuffing box. Bronze casting shall conform to ASTM B 584 or better. Type of stainless steel shall be 304, 420 or others. The finish of the sleeve at the seal faces shall be highly polished (15 microns). Where a pump is drawing water from a river intake stainless steel sleeves shall be fitted.

The diameter of the sleeve shall not be taken into account when calculating shaft stiffness.

(ii) Balance

The whole of the rotating assembly, including impeller locking key(s) but excluding the impellers shall be dynamically balanced as an integral component. The impellers shall be dynamically balanced separately and then assembled to the shaft, to form without further adjustment, a dynamically balanced whole.

(h) Mounting

(i) Horizontal Mounting

Horizontal pump sets shall have the pump and motor mounted on a common bedplate of cast iron or fabricated steel which shall incorporate machined reference surfaces to permit levelling of the assembled pump set on its foundation. The bedplates shall be fully supported on sets of steel packers and shims which shall be not less than 80mm wide or twice the width of the bedplate frame and drilled for positive location. Not more than one packer and two shims shall be used at each location point.

The pump shall be mounted on and bolted to the bedplate and unless positively located be dowelled in its final position with not less than 0.75mm, of brass shimming between the pump and bedplate. The motor shall not be dowelled until after final alignment on site has been checked and approved by the Employer's Representative. Dowel pins shall be Grade A in accordance with BS 1804 Part 3 or equivalent.

(ii) Vertical Mounting

Close-coupled

Close-coupled pump sets complete with motor shall be mounted on a rigid stool incorporating the coupling, coupling guards and thrust bearing where applicable.

Shaft Driven

Where the design requires the pump to be mounted on a separate floor below the drive motor because of the possibility of pump room flooding or for the purposes of locating motors adjacent to switchgear, shaft driven pumps shall be provided. The shaft may be open or enclosed and shall incorporate intermediate steady bearings as determined by the transmitted power, speed, length and diameter. Intermediate shaft lengths shall not exceed 3m and shall run below their first critical speed, vibration free.

The shaft shall be supported such that the weight of the shaft is not transmitted to the pump and motor bearings. A thrust bearing assembly shall be incorporated into the drive motor stool to take the weight of the shaft and include all necessary ventilation and cooling coils if required.

Each intermediate shaft shall be independently supported and designed such that there is no transmission of vibration between supports via walkways, support steelwork etc.

The Contractor shall be responsible for the provision and erection of all support steelwork for the support bearings and shall undertake vibration studies as required to ensure that vibration effects are not transmitted to the supporting structures and/or buildings which may impart resonance effects to those structures/buildings.

Support Stool

The support stool shall be manufactured from either close grained cast iron or fabricated steel. The stool shall be founded on a separate foundation plate permanently bolted and grouted to the structural floor; the motor stool shall be located relative to the motor by a machined spigot flange and to the foundation plate by the same or dowel pins together with the necessary number of securing bolts. The upper face of the motor stool shall not be less than 600mm above the finished motor room floor level.

Bearings

The intermediate bearings shall be self-aligning ball or roller type housed in Plummer blocks fixed and dowelled to the supporting steelwork.

Lubrication

Lubrication points or support bearings, universal joints, sliders, etc. shall be readily accessible from permanently fixed access platforms provided under the contract or piped to ground level unless otherwise specified.

Balance

After manufacture and assembly, including setting pre-load in the universal coupling bearings, the shaft assembly shall be dynamically balanced.

(i) Couplings

(i) General

Couplings shall be provided to permit the removal of drive shafts, bearings, etc. without removing the pump or motor. Couplings between the thrust bearing and motor shall be accommodated within motor/support stools.

Couplings shall be of the pin and buffer type unless otherwise specified.

(ii) Coupling Alignment

After coupling alignments the Employer shall witness and accept the machine alignments which shall be recorded in accordance with BS 3170 or equivalent.

(j) Rating Plates

Rating plates shall be fitted to all pumps, be manufactured and fixed by corrosion resistant material (excluding brass) and include full details of the pump including size, type, serial number, best efficiency, duty point flow, head, speed, NPSH and the closed valve head.

The weight of the pump set, motor and bedplate or stool shall be marked on the pump set data plate.

(k) Guarding

All machine enclosures shall be safeguarded in accordance with BS 5304 or equivalent and with guards fixed to either the pump set bed plate or motor stool whichever is appropriate. Couplings shall be totally enclosed.

Shaft guards shall extend the whole length of the shaft and include hinged access doors at lubrication/inspection points for couplings, bearings, sliding joints, etc. Mesh sizes or apertures in the guard shall not exceed 12mm diameter or 12mm square.

(l) Lifting Brackets

Integral lifting brackets, shackles and lifting eyebolts shall be manufactured from stainless steel with minimum ultimate tensile strength of 540 MN/m^2, and certified in accordance with BS 4278 or equivalent. Both bolt and hole shall be permanently marked, preferably by punching, with the diameter and thread form used. All eyebolts shall be of the collar type.

1.3.4 Pump Types

Water pumps shall generally be divided into two groups. Raw water and potable water pumps may be of the following types, depending on the application and as specified in the Particular Specifications:

1 Borehole Pumps
2 Electro-submersible
3 Back pull-out
4 Double Entry Pumps
5 Multi-stage ring Pumps
6 Hydro-pneumatic boosters.

(a) Borehole Pumps

Borehole pumps shall be multi-stage cast iron mixed flow or centrifugal pumps suspended below the motor/thrust bearing/head gear which shall be mounted under cover. The pump and associated rising main pipe column shall be supported separate to the motor and thrust bearing stools. The rising main shall be flanged and provision made for cabling to borehole or wet sensors and/or intermediate bearing lubrication lines where applicable.

Pump shafts shall be stainless steel and bearings shall be water lubricated bronze. Water lubricated rubber bearings are permitted provided there is no possibility of the pump running dry. The pump inlet shall be fitted with a stainless steel strainer and the cutlet shall be fitted within a positively seating bronze check valve (this is in addition to the reflux valve associated with the wellhead pipework).

(b) Electro-submersibles

Electro-submersible pumps shall be used in deep well applications and where borehole casing sleeves are less than 350mm internal diameter. They may also be used horizontally as “in-line booster” applications where required by the Contract in pipes of 150mm diameter or less.

In borehole and in-line applications the motor shall be arranged upstream of the pump inlet and cooling water flow over the motor shall be unimpeded.

In horizontal applications the pump and motor shall be fully supported by adjustable radial supports at a maximum of 1200mm centres, with not less than two sets per pump set.

Pumpsets in casings below 100mm diameter may be of fabricated stainless steel construction inclusive of shaft casings, impellers and check valve.

Pumps shall be of vertical submersible turbine type consisting of turbine bowl assembly and submersible motor, and be supplied complete with electric cables.

Stainless steel nameplates with stamped or engraved pump data giving the name of the manufacture, model number, serial number, rated capacity (lps), head (m) per stage, number of stages, and speed shall be attached to both the head assembly and the pump bowl.

Except as otherwise provide in these specifications, the pump and motor assembly and accessories shall conform to AWWA E101. “Deep Well Vertical Turbine Pumps - Line Submersible ‘types”

Bowl shall have threaded joints made of close grained cast iron. ASTM A48 class 30, be water lubricated and be provided with bronze bearings.

The impellers shall be of the enclosed type, made of one piece cast bronze conforming to ASTM B584, or stainless steel and secured to the shaft with tapered steel collars. All impeller surfaces shall be smooth; they shall be statically and dynamically balanced for maximum efficiency and performance.

Suction strainers shall be stainless steel with opening sized to exclude any object that might damage the impellers.

The pump shafts shall be stainless steel conforming to ASTM A267. Type 410 or 416, and shall be adequately supported by bronze bearings. The shafts shall be forged, ground and sized to provide minimum deflection.

The upper end of the pump shaft shall be polished to a fine surface to give thrust protection against the bronze, grease lubricated plate type bearings.

There shall be an extra long bronze inter-connector bearing that will provide maximum shaft support at the point where the motor shaft joins the pump shafts.

Should riser pipes be required, they shall not be lighter than schedule 40 seamless steel pipe furnished in 3.0 metres maximum lengths and shall be connected with extra strong threaded couplings.

Surface plates - The surface plate shall be fabricated from heavy gauge steel plate

(c) Back-Pull out Pumps

Where single stage pumps are suitable for the design duty, over hung impeller back pull-out type pumps may be offered for water pumping applications, e.g. small boosters, supernatant return, etc. Horizontal installations close or long-coupled are preferred but vertical applications are acceptable where applicable.

The hydraulic end and drive shall be easily removed without affecting the associated pipework. The casing and bed-plate assembly shall incorporate locating rails as part of the back pull-out arrangement.

Dynamic thrust shall be taken by suitable thrust bearings incorporated in the long-couple arrangement or the motor bearings and shall be rated to take the hydraulic end loading.

(d) Double Entry Pumps

Potable water pumps shall be horizontal, axially split, double entry pumps complete with mechanical seals unless otherwise indicated in the Contract documentation.

The pumps shall be single stage, double suction, horizontally split case type, centrifugal pumps suitable for continuous heavy duty service. The construction of the pumps shall be such that no damage will occur to the pump, attached motor or controls if reverse rotation takes place. Mechanical brakes or ratchets shall not be permitted. No non-metallic materials will be allowed in the inside of the pump casing or impellers where a vertical arrangement is required the motor shall be supported by an independent rigid stool.

(e) Multi Stage Ring Pumps

For high head applications multi-stage ring pumps shall be provided. Hydraulic balance shall be-incorporated within the pump design. Balance and air release pipes shall be copper or stainless steel. Air release lines shall drain into a single bed plate tundish. Manifolding is not permitted.

(f) Hydro-pneumatic Boosters

Hydro-pneumatic booster sets shall comprise duty/standby pumpsets, air/water accumulator and associated valves and pipework all mounted on a common bedplate.

The pumps shall be complete with cast iron case sections, stainless steel impellers, stainless steel shaft, water lubricated bronze intermediate bearings and tungsten carbide mechanical seals. Pump connections shall be flanged.

Single stage back pull-out pumps are a permitted alternative where efficiency and economy of supply allow.

The air/water accumulator shall be a cylindrical steel diaphragm accumulator vessel complete with taint free butyl liner, polypropylene water compartment liner, pressurized air (or nitrogen) charge and Schrader valve. A pressure gauge shall be provided visible from the front of the booster package or control panel.

The vessel shall be certified and marked in accordance with BS 5500 or equivalent.

The pipework shall be galvanised to BS 1387 or equivalent and comprise a suction manifold connecting the pump suction and a delivery manifold connecting pump delivery and the air/water accumulator both terminating as flanges to BS4504 or equivalent PN16. The accumulator and pumps shall be provided with isolating wedge gate valves and the pump non-return valves of the wafer pattern type.

Each pump suction shall be provided with a suction protection pressure switch and control pressure switches shall be provided on the suction and delivery manifolds.

(g) Sump Pumps

Where specified, sump pumps shall be provided in dry wells where natural drainage is not possible and in wet sumps which are required to be fully drained down.

Sump pumps shall be fully automatic with integral non-mercury level control switches. Integral level float switches shall not operate on mains voltage. They shall be free standing and suitable for use with 300mm by 300mm by 300mm drainage sumps.

Delivery pipework shall be ABS terminating with a ball type refiux valve and isolating valve adjacent to the drainage sump. Pump discharge connection system shall be specified as the following two types:

(a) Quick gravity connection system

(b) Quick coupling system for flexible pipe

Flexible hose shall connect the pump to the pipework to facilitate removal of the pump without affecting the pipework.

1.3.5 Factory Performance Tests

Unless otherwise specified, all pumps shall be tested at the manufacturer's plant to demonstrate complete compliance with these specifications. The tests shall be in full compliance with the applicable provisions of ISO 3555, and as herein noted.

Unless waived in writing by the Engineer, all tests shall be witnessed by a duly authorized representative of the Engineer. The Contractor shall provide 30 days notice to the Engineer in writing prior to conducting factory tests.

The tests shall cover the entire range of total head from shut-off to the minimum total head at which the pump can operate without cavitation, noise, or vibration with suction pool water level as low water elevation. The minimum head shall be equal to or less than the run out head specified for each pump. Data shall be recorded for not less than five points between shut-off and the minimum total head for suction

pool low water elevation. After factory performance tests, the Contractor shall submit six (6) copies of test reports.

If the pump fails to meet the specified head capacity efficiency requirements or indicate cavitation or damaging noise or vibration in the total head range between shut-off and specified run out heads, the pump shall be modified or newly manufactured until acceptable tests are completed.

1.3.6 Shop and Field Painting

The pumps, couplings, motors and bed plates shall have shop and field coats. All interior ferrous and non-machined surfaces of casings shall be shop painted with tar epoxy paint, Paint System E1 unless otherwise specified.

Painting shall conform to the requirements as specified in the SECTION 1.10 'PAINTING AND PROTECTIVE COATING' unless otherwise specified.

1.4 Valves and Actuators

1.4.1 General

Valves shall be suitable for use with water or water works sludge at all temperatures of up to 45°C and at high humidity.

All valves shall have following marking and they shall be designed cast in raised letters upon some appropriate part of the body.

- Name of the Owner "NWSDB"
- Name and mark of manufacturer
- Year of manufacturing, 01 (means 2001)
- Working pressure, NP10 (means 0.98 MPa) and
- Arrow direction for valves designed for one-way flow only.

Valve ends shall be flanged ends except where otherwise specifically specified elsewhere. Where flanged ends are used, mating dimensions and drilling shall be in accordance with the flange schedule specified in SECTION 1.2.9 FLANGED JOINTS.

Thickness of flanges shall conform to internationally accepted standards, or the Contractor shall determine the flange thickness and shall submit his design calculation.

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

Valves shall be equipped with hand lever, hand wheels, chain or hand, pneumatic or electric operators. Unless otherwise specified, manual operation valves shall have hand wheels. Valves shall open by turning to the left or counter clockwise. Operators shall have arrows cast thereon to indicate the direction of rotation for opening the valve.

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

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

1.4.2 Valves

(a) General

Valves shall be suitable for their application and media being passed and installed in such a manner as to allow ease of operation and maintenance.

The use of dissimilar metals in conjunction in a corrosive environment shall not be permitted, e.g. steel pipes and non-ferrous valves.

Valves used in water treatment process plant shall be suitable for use with the chemicals associated with the process, e.g. chlorine, coagulants, polyelectrolyte, lime, etc.

Valves and penstocks located outside buildings shall be provided with a locking device where operation will be critical to the process or plant being controlled or isolated.

Valve gearboxes shall be provided where necessary to allow handwheel operation at maximum differential pressure. Gearboxes are to be fully enclosed.

All valves shall be capable of drip-tight isolation of the free end of an unsupported pipe and be capable of manual operation under maximum head conditions.

Valve selection shall be as follows unless otherwise specified.

Pump Isolation - Wedge Gate Sluice or Knife Edge Gate or Flanged Butterfly.

- Water Control/Isolation - Butterfly, Ball, Eccentric Plug, Globe, Axial Sleeve or Roll Seal.
- Sludge Control - Eccentric Plug or Knife Edge Gate.
- Chemical Dosing - Diaphragm or Ball.
- Slurry lines (e.g. Lime) - Wireless Diaphragm.
- Sampling - Diaphragm or Ball.
- Gas Control - Diaphragm or Ball.
- Non-return or reflux valves shall be fitted downstream of all pumping plant. Where indicated in the specification that the valves have to close within a designated surge transient return time they shall be suitably rated for that condition by the use of spring assistance.

Valves for gas application shall be fire safe.

Where pressure differential is expected to create difficulty in the operation of a valve, a ball thrust collar, gearing or motor operation shall be provided. By-pass valves are permitted as an alternative where hydraulic balance is possible and becomes a pre-condition to valve opening.

Valves up to 40mm inclusive shall have screwed socket-welded or flanged ends according to service conditions and pipework layout.

Valves larger than 40mm shall have flanged ends unless otherwise specified.

Sluice valves to BS 5163 or equivalent for PNI6 Double Flanged Cast Iron, Wedge Gate Valves for Waterworks shall be provided as “boundary valves on all elements of the process stream.

Sluice valves installed within the confines of building shall be type A and those installed within valve chambers or underground shall be type B. They shall have bodies of high quality cast iron and those above 300mm shall be fitted with renewable body seat rings of gunmetal. The wedge shall be of cast iron with

renewable wedge face rings of gunmetal and the non-rising spindle shall be of manganese bronze.

All sluice valves shall be fitted with hand wheels unless otherwise specified. Stem caps shall be provided on all valves detailed for key operation and shall be secured with socket headed set screws.

Sealing shall be so arranged that replacement can be accomplished with ease and shall not require the removal of the valve from the pipeline. Unless otherwise specified stem sealing shall by toroidal 'O' ring seal. Where a conventional stuffing-box arrangement is specified, the packing shall be non-asbestos.

The dimensions of a gate valve fitted with a by-pass valve shall not exceed the basic dimensions set down in BS 5150 or equivalent and BS 5163 or equivalent.

Valves of 600mm nominal diameter, or larger shall be fitted with a wedge re jacking screw and locknut.

(b) Testing

(i) General

The manufacturer shall notify the Engineer at least thirty working days prior to factory tests. The Engineer reserves the right to witness all tests.

(ii) Performance Tests

Each valve, gate and appurtenance shall be shop-operated three times from the fully closed to the fully opened position, and the reserve, under a no-flow condition, to demonstrate that the complete assembly is workable.

(iii) Leakage Tests

Valves, gates and appurtenances shall be shop-tested for leaks in the closed position. With the valve in the closed position, hydrostatic pressure as directed by the Engineer shall be supplied to one face of the disc for the full test duration at the working pressure. The length of test shall be at least 5 minutes and there shall be no indication of leakage past the valve during the test period.

(iv) Hydrostatic Tests

Valves specified shall be hydrostatically tested. Hydrostatic tests shall conform to the following:

With the valve disc in a slightly open position, internal hydrostatic pressure equivalent to 150% of the specified working pressure shall be applied to the inside of the valve body of each valve for a period of 10 minutes. During the hydrostatic test, there shall be no leakage through the metal, the end joints, or the valve shaft seal; nor shall any part be permanently deformed. While undergoing testing, the valve body shall be struck with a hammer several times.

(v) Field Testing

When the valves, gates and appurtenances have been completely installed and as soon as operation conditions permit, they shall be given a field test by the Engineer to demonstrate that they have been suitably installed, that they meet all requirements, are in good operating condition and are, in every way, adequate for the service intended.

(c) Painting

All valves, gates and appurtenances, unless otherwise specified, shall be shop primed on the exterior in accordance with the SECTION 1.10 'PAINTING AND PROTECTIVE COATING' unless noted otherwise.

All valves, gates and appurtenances, unless otherwise specified, shall have an interior ferrous port, except finish or bearing surface, painted with two (2) coats of epoxy paint or coal tar epoxy paint having total minimum dry film thickness of 0.4 mm. Material of the said epoxy paint or coal tar epoxy paint shall conform to AWWA C210 or shall be certified by the recognized public health authorities for linings in potable water service.

(d) Gate Valves

(i) General

The following Gate valves shall be specified hereinafter:

- Gate Valves, Normal Pressure Service, NP 10 (50mm to 500 mm)
- Gate Valves, High Pressure Service, NP 16 (50 mm to 300 mm)
- Resilient-seated Gate Valves (80 mm to 300 mm)
- Bronze Gate valves (80 mm and smaller)
- Stainless Steel gate Valves (15 mm to 300 mm)

(ii) Reference

The following standards are referred to:

BS 5163	Sluice Valves for Waterworks
ASTM B 584	Bronze Casting
AWWA B115	10kgf/cm2 Sluice Valves for Waterworks
AWWA B120	Resilient Seated Gate Valves for Waterworks
AWWA C210	Liquid Epoxy Coating System for the Interior and Exterior of Steel Water Pipelines
AWWA C213	Fusion-bonded Epoxy Coating for the Interior and Exterior of Steel water Pipelines
AWWA C500	Gate Valves, 3 through 48 in. NPS, for Water and Sewage Systems
AWWA C509	Resilient-seated Gate Valves, 3 through 12 NPS, for Water and Sewage Systems.
BS 5163	Metric Specification for General Purpose Cast Iron Wedge Gate Valves.

(iii) Gate Valves, Normal Pressure Service, Class NP 10 (50mm to 500mm)

Gate valves, normal pressure service, working pressure of 0.98 MPa shall be cast iron or ductile iron body, bronze-mounted, non-rising stem (NRS) type gate valves and shall be designed and manufactured in accordance with AWW C500, BS 5163 or AWWA B115 and in addition shall conform to the following requirement:

Stem shall be of cast, forged or rolled bronze or copper alloy or mantensitic series stainless steel. Stem sealing shall be of stuffing box or O-ring type. Packing for the stuffing box shall be made of nylon. Asbestos or hemp of jute packing materials shall not be used. O-ring stem seals shall have a minimum of two (2) "O" ring seals, of which at least one (1) shall be above the stem collar and replaceable under full working pressure while the valves is in fully open position.

(iv) Gate Valves, High Pressure Services, Class NP 16 (50mm to 300mm)

Gate valves, high pressure service, design working pressure of 1.568 MPa shall be cast iron or ductile iron body, bronze-mounted, non-rising stem (NRS) type gate valves and shall be designed and manufactured in accordance with BS 5163 or other international accepted standard.

Valves shall conform to all provisions specified in the previous sub-section (iii) Gate Valves, Normal Pressure Service, Class NP 10.

(v) Resilient-Seated Gate Valves (50mm to 30mm)

The valves shall be cast iron or ductile iron body resilient-seated gate valves and shall be designed and manufactured in accordance with AWWA B120 or BS 5163 or other international accepted standard. Design working pressure shall be of 1.568 MPa.

Valves shall be designed to provide an unobstructed waterway having a diameter of not less than the full nominal diameter of the valve when in the open position.

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

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

In addition to the requirement specified above, valves shall conform to all provisions specified in the previous Sub-section (iii) Gate Valves, Normal Pressure Service, and Class NP 10.

(vi) Bronze Gate Valves (80mm and Smaller)

Bronze Gate Valves shall be designed and manufactured for working pressure of 0.98 MPa. Valves shall be equipped with either screwed ends or flanged ends.

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

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

The body shall be bronze casting conforming to ASTM B 584 or bronze casting having tensile strength not less than 196 N/mm^2. Disc shall be bronze casting specified above or copper having tensile strength not less than 314 N/mm^2. Stem shall be copper specified above.

(vii) Stainless Steel Gate Valves (15 mm to 300 mm)

Stainless steel gate valves shall be solid wedge disc type valves with outside screw-and-yoke (OS&Y) rising stems and designing for handling acids. Valves shall have hand wheels and flanged ends. Working pressure shall be 0.98 MPa.

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

(e) Butterfly Valves

(i) General

The following butterfly valves shall be specified hereinafter:

(a) Butterfly Valves, Class NP 10
(b) Butterfly Valves, Class NP 16
(c) Toothed Vane Rotary Control Valves
(d) Wafer Butterfly Valves (50 mm to 600 mm).

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

(ii) References

The following standards are referred to:

BS 1452	Gray Iron Casting
BS EN 1563	Spheroidal Graphite Iron Casting
AWWA C504	Rubber-seated Butterfly Valves
BS 5155	Butterfly Valves
ISO 5752	Metal Valves for use in flanged pipe systems – face to face and centre- to-face dimensions

(iii) Butterfly Valves - Class NP 10

Valves shall be double flanged, cast iron or ductile iron short body, rubber-seated butterfly valves, and shall be designed and manufactured basically in accordance

with AWWA C504 or BS 5155 and in addition shall conform to the following requirements.

Valves shall be designed to be leak tight in both directions at a maximum working pressure of 0.98 MPa and at a maximum differential pressure of 0.98 MPa across the valve disc, and shall be suitable for a maximum velocity of 4.8 m/sec and for throttling service.

Laying length of valves shall conform to Type I and Type II specified in the following Table A. Valve bodies shall be designed to withstand the design requirements specified.

TABLE A: LAYING LENGTH OF VALVES

VALVE DIAMETER (mm)	TYPE I (mm)	TYPE II (mm)
80	127	114
100	127	127
150	127	140
200	152	152
250	203	165
300	203	178
350	203	190
400	203	216
450	203	222
500	203	229
600	203	267
700	305	292
800	305	318
900	305	330
1000	305	410
1100	305	470
1200	381	470
1400	381	530
1500	381	600
1600	457	600
1800	457	670

Each shaft shall be a one-piece unit extending completely through the valve disc, or of the “stub shaft” type, which comprises two separate shafts inserted into the valve disc hubs. If of “stub” construction, each stub shaft shall be inserted into the valve disc hubs for a distance of at least 1.5 times the shaft diameter.

Materials of shaft shall be either austenite series stainless steel, Type 304 or 316, or high yield strength mantensitic series stainless steel. If Type 304 or 316 stainless steel are used, a minimum diameter extending through the valve bearings and into the valve disc shall be as specified in the following Table B.

TABLE B: MINIMUM SHAFT DIAMETER

VALVE DIAMETER (mm)	MINIMUM SHAFT DIAMETER (mm)
80	12.7
100	15.9
150	25.4
200	28.6
250	34.9
300	38.1
350	44.5
400	50.8
450	57.2
500	63.5
600	76.2
700	85.7
800	98.4
900	111
1000	120
1100	133
1200	143
1400	178
1500	187
1600	193
1800	216

Note: * Based on use of stainless steel, Type 304 or 316.

If high yield strength martensitic series stainless steel such as Type 403, 420, 431 and others are used for the valve shaft, allowable torsional shear stress, not exceeding 25% of yield strength of the material used, shall be applied for design of valve shaft diameter.

Valve discs shall be made of cast iron or ductile iron or stainless steel casting and shall be of design with no external ribs transverse to the flow. The design of disc shall withstand full differential pressure across the closed valve disc without exceeding a working stress, equivalent to 20% of tensile strength of the material used.

Rubber seats shall be applied to either the body or the disc, shall be of synthetic rubber, and may be reinforced. Rubber seats of valve 700 mm in diameter and larger shall be of a design that permits removal and replacement at the site of the installation. Rubber seats shall be clamped, mechanically secured, or bonded to the body or disc. Rubber seats shall mate with stainless steel seating surface. Clamps and retaining rings for rubber seats shall be made of stainless steel and hardware used with clamps and retaining rings shall be stainless steel.

Valves shall be fitted with sleeve type bearings contained in the hub of the valve body. Valves, 350 mm in diameter and larger shall be equipped with either one or two thrust bearings, which shall hold the valve disc securely in the center of the valve. Sleeve and other bearings fitted into the valve body proper shall be made of self-lubricated materials that do not have a harmful effect on potable water or rubber.

A shaft seal shall be provided where shafts project through the valve bodies for actuator connection. Shaft seals shall be designed for the use standard V-type packing; O-ring seals; O-ring-loaded, U-cup seals; or a pull-down packing. If O-rings are used, they shall be contained in a stainless steel or bronze removable recesses. If stuffing box and pull-down packing gland are used, the design of the valve and stuffing box assembly shall permit adjustment or complete replacement of packing without disturbing any part of the valve or actuator assembly except packing gland follower.

Gland or gland assemblies shall be made of stainless steel or bronze. Packing shall be made of resilient, non-metallic material suitable for potable-water service which shall not contain asbestos.

(iv) Butterfly Valves, Class NP 16

Valves shall be double flanged, cast iron or ductile iron short body, rubber-seated butterfly valves. Valves shall be designed leak tight in one direction at a maximum working pressure of 1.568 MPa, and shall be suitable for a maximum velocity of 3.0 m/sec and for throttling service.

Valves shall conform to all provisions specified in the previous sub-section, (iii) Butterfly Valves, Class NP 10, except the following items and in addition shall conform to the following requirements.

Valve bodies shall be designed to withstand the maximum working pressure specified and a maximum differential pressure of 0.98 MPa. Minimum thickness of valve body shall be calculated without exceeding a working stress equivalent to 20% of the tensile strength of the materials used.

Valve shafts shall be of high yield strength mantensitic series stainless steel such as Type 403, 420, 431 and others and valve shafts made by precipitation series stainless steel may be acceptable. Allowable torsional shear stress, not exceeding 25% of yield strength of material used shall be applied for design of valve shaft diameter.

Valve discs shall be designed to be off-centered. Rubber seats of valve shall be of a design that permits removal and replacement at the site of the installation without removing shafts from the valve body.

(v) Toothed Vane Rotary Control Valves

Valves shall be rubber seated, toothed vane disc butterfly type rotary control valve and shall conform to all provision in the previous sub-section, (iii) Butterfly Valves.

Class NP10, except the following items and in addition shall conform to the following requirements.

Valves shall be designed to be leak tight, in both directions at a maximum working pressure of 0.98 MPa and shall be suitable for a maximum velocity of 3.0 m/sec and for throttling service.

Valves shall have hydrodynamically designed toothed vane, which splits up the flow stream and reduces noise and cavitation effectively while providing precise flow control.

Valve bodies shall be double flanged long body type and shall be made of ductile iron conforming to ISO 2531.

Shafts shall be of high yield strength mantensitic series stainless steel such as type 403, 420, 431 and others. Allowable torsional shear stress, not exceeding 25% of yield strength of the material used, shall be applied for design of valve shaft diameter.

Valve discs shall be designed to be centered.

Rubber seats shall be applied to the body and shall be clamped, mechanically secured, bonded, or vulcanized. Design of removal and replacement of rubber seats will not be required.

(vi) Wafer Butterfly Valves

Valves shall be cast iron or ductile iron wafer body, rubber-seated butterfly valves, and shall be designed and manufactured basically in accordance with BS 5155 or equivalent international standard and in addition shall conform to the following requirements:

Valves shall be designed to be leak tight in both directions at a maximum working pressure of 1.568 MPa and at a maximum differential pressure of 0.98 MPa and at a maximum velocity of 4.0 m/sec and for throttling service.

Laying length of valves shall conform to laying length as specified in the following Table C. Valve bodies shall be designed to withstand the design requirements specified.

TABLE C

VALVE DIAMETER (mm)	LAYING LENGTH (ISO 5752 Water Short Series)
50	43
65	46
80	46
100	52
150	56
200	60
250	68
300	78
350	78
400	102
450	114
500	127
600	154

Each shaft shall be a one-piece unit extending completely through the valve disc, or of the "stub shaft" type, which comprises two separate shafts inserted into the valve disc hubs. If of "stub"construction, each stub shaft shall be inserted into the valve disc hubs for a distance of at least 1.5 times the shaft diameter.

Valve shafts shall be of high yield strength mantensitic series stainless steel such as Type 403, 420, 431 and others and valve shafts made by precipitation series stainless steel may be acceptable.

Valve discs shall be made of stainless steel casting and shall be of centered design with no external ribs transverse to the flow. The design of disc shall withstand full differential pressure across the closed valve disc.

Rubber seats shall be spool shaped rubber seating applied to the body and shall be made of EPDM or Buna-N (NBR).

Allowable stress, not exceeding 20% of yield strength of cast iron or ductile cast iron and allowable stress, not exceeding 30% of yield strength of stainless steel shall be applied for design of major parts of valve.

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

(f) Check Valves

(i) General

The following check valves shall be specified hereinafter:

(a) Swing Check Valves (50 mm to 600 mm)
(b) Bronze Swing and Lift Check Valves (50 mm and similar)
(c) Stainless Steel Check Valves (15 mm to 300 mm)

(d) Tilting Disc Check Valves (50 mm to 1,500 mm)
(e) Wafer Check Valves (50 mm to 1,200 mm)
(f) Spring Loaded Lift Check Valves (25 mm to 400 mm).

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

(ii) References

The following standards are referred to:

BS 5150	Cast Iron Gate Valves
ASTM B 584	Bronze Castings
API 594	Wafer Check Valves

AWWA C508 Swing-Check Valves for Waterworks service, 2 in. through 24 in. NPS.

(iii) Swing Check Valves (50 mm to 600 mm)

Swing check valves shall be cast iron body and disc, and bronze seating type. The valves shall be designed and manufactured in accordance with AWWA C508. Working pressure shall be 0.98 MPa.

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

Valves shall be furnished with hinge arms, levers and springs or weights and also furnished with a by-pass pipe and by-pass valve.

(iv) Bronze Swing and Lift Check Valves (50 mm and smaller)

Bronze swing and lift check valves shall be designed and manufactured for a working pressure of 0.98 MPa. Valves shall be equipped with screwed ends.

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

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

The body shall be bronze casting, and bonnet and disc shall be of bronze casting or copper. The said bronze casting and copper shall conform to the requirements specified in SECTION 1.4.2 (d) vi) BRONZE GATE VALVES (80 mm and smaller)

(v) Stainless Steel Check Valves (15 mm to 300 mm)

Stainless steel check valves shall be straightway, swing type and designed for handling acid. Valves shall have metal to metal seating. Working pressure shall be 0.98 MPa.

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

Unless otherwise specified, major parts of the valve such as body, bonnet, disc, hinge with hinge pin and other parts which may contact with handling liquid shall be made of Type 316 stainless steel casting.

(vi) Tilting Disc Check Valves (50 mm to 1,500 mm)

Tilting disc check valves shall be cast iron or ductile cast iron body and disc, and bronze or stainless steel seating. Valves shall be designed for a working pressure of 1.568 MPa and shall be suitable for operation in a horizontal pipeline.

Body shall be two (2) piece construction bolted together. Seat rings shall be mounted on both valve body and disc and shall be made of bronze casting conforming to ASTM B 584 or Type 304, 403, 420 or other stainless steel. Mating surfaces of body seat and disc seats shall be machine finished. Hinge pin shall be of stainless steel specified above. Bushings of hinge pin shall be bronze casting or aluminium bronze casting.

Body shall be provided with suitable hand holes for cleaning and by-pass pipe with valve. Pivot pin housing shall be fitted with ball check grease fittings.

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

(vii) Wafer Check Valves (50 mm to 1,200 mm)

Wafer check valves shall be dual plate, two spring-loaded, semi-circular plates type. The valves shall be designed and manufactured in accordance with API 594, or other internationally accepted standards.

Valves shall be designed to fit between two pipe flanges and for working pressure of 1.568 MPa.

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

Unless otherwise specified, the spring shall be high Torque type.

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

Spring loaded lift check valves shall be cast iron body, spring loaded, center guided disc type with flanged ends. Valves shall be designed for a working pressure of 0.98 MPa.

The valves shall be suitable to operate in a vertical position with flow upward and shall consist of body, disc, upper guide, disc guide, reverse flow guide disc, spring and by-pass valve.

Body seat ring shall be bronze casting accurately threaded and screwed into the body. Disc shall have synthetic rubber seat bolted to the disc. Disc, upper guide, disc guide and by-pass valve shall be of bronze casting conforming to ASTM B 584. Spring shall be Type 304 stainless steel.

(g) Globe Valves

(i) General

The following globe valves shall be specified hereinafter:

(a) Angle hose valves (10 mm to 100 mm)
(b) Hose bibs (13 mm to 25 mm)
(c) Stainless steel globe valves (15 mm to 300 mm).

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

(ii) References

BS 5159 Faucets and Ball Taps
ASTM B 584 Bronze Castings.

(iii) Angle Hose Valves (10 mm to 100 mm)

Angle hose valves shall be bronze body Y-Gloss valves with renewable composition discs. Valves shall have rising stem and screwed ends with stainless steel replaceable quick couplings cap. Working pressure shall be 0.98 MPa..

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

Disc holder shall be made of bronze casting conforming to ASTM B 584.

(iv) Hose Bibs (13 mm to 25 mm)

Hose bibs shall be bronze body globe valves with renewable composition discs. Valves shall have rising stems, screw-in bonnet, screwed inlet and hose coupling outlet. Working pressure shall be 0.74 MPa. Valves shall be designed and manufactured in accordance with BS 5159 and shall be swivel nose faucet, faucet with hose coupling or lawn faucet.

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

(v) Stainless Steel Globe Valves (15 mm to 300 mm)

Stainless steel globe valves shall be metal-to-metal seating type globe valves with outside screw-and-yoke (OS&Y) rising stems and designed for handling acids. Valves shall have flanged ends and a net-flow area not less than the area of a circle with a diameter equal to the nominal pipe size. Working pressure shall be 1.568 MPa.

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

(h) Diaphragm Valves

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

The valves shall be used in water, air, and weak chemical service lines.

The reinforced rubber diaphragm shall be connected to a spindle actuated compressor so that it will be lifted to provide an adequate water-way for minimum pressure loss.

Further, the diaphragm shall be forced tight against the body even when the compressor is lowered. The diaphragm shall seal the bonnet compartment and working parts from the fluid stream. The diaphragm shall be capable of ready replacement without removing the valve body from the pipeline.

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

(i) Pressure Reducing Valves

Pressure reducing valves for plant water service shall be cast iron body, self-contained, direct-acting, spring-loaded type. Valves shall operate at a primary pressure range of 0 to 0.98 MPa and at an adjustable secondary pressure range of 0.1 to 0.4 MPa .Valves shall have flanged ends and the working pressure shall be of 0.98 MPa.

All ports subject to wear shall be accessible for repair or replacement without removing the valve from the line. Secondary pressure of valve shall be designed to be adjustable without any use of special tools while it is in service.

In all cases of pressure reducing valves installation, suitable cast iron body strainers shall be provided on the primary side of the valve. Two (2) gate valves, one for the primary side and the other for the secondary side of the pressure reducing valve shall be provided and by-pass line with gate valve shall be also provided. These gate valves specified above shall be the same size as the pressure reducing valve.

Two (2) pressure gauges, one for the primary side and the other for the secondary side of the pressure reducing valve shall be provided.

(j) Air Valves

(i) General

The following air valves shall be specified hereinafter:

(a) Single orifice type air valves (25 mm)
(b) Double orifice type and combination type air valves (50 mm to 150 mm).

All air valves mentioned above shall be constructed so that internal working parts which may become necessary for repairs shall be readily accessible, removable, and replaceable without use of special tools and removing the valve from the line.

(ii) References

The following standard is referred to:

BS EN 1074 Air Valves for Waterworks.

(iii) Single Orifice Type Air Valves (25 mm)

Single orifice type air valves shall be cast iron body and single float actuated air valves with flanged ends. Valves shall be designed and manufactured to a working pressure of 1.568 MPa.

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

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

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

(vi) Double Orifice and Combination Type Air-Valve (50 mm to 150 mm)

Double orifice and combination types shall be cast iron body and double float actuated air valves with flanged ends. Working pressure of all air valves shall be 1.568 MPa.

Double orifice and combination types shall be designed to automatically operate so that they will:

(a) Positively open under internal pressure less than atmospheric pressure to admit air in bulk during pipeline draining operation;
(b) Exhaust air in bulk and positively close as water, under low head, fills the body of the valve during filling operation;
(c) Not blow shut under high velocity air discharge; and
(d) Exhaust accumulated air under pressure while the pipe is flowing full of water.

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

Combination type air valves shall be furnished with stop valve which shall have flanged ends.

Double orifice type and combination type air valves shall be applied for pipelines 350 mm in diameter and larger unless otherwise specified.

(k) Foot Valves

Foot valves shall be cast iron body, swing type foot valves with renewable composition disc. Valves shall have flanged ends. Valves 100 mm in diameter and smaller shall be designed for a working pressure of 0.98 MPa. Valves 150 mm in diameter and larger shall be designed for a working pressure of 0.49 MPa.

Valves shall have cast iron strainer and valves 300 mm in diameter and smaller shall have a valve disc knocking lever with suitable size of stainless steel chain extended to the operation floor. A net-flow area through the valve port shall be at least 75% of the area of a circle with a diameter equal to the nominal pipe size. The valve seat shall be designed to ensure positive water tight shut-off at low head pressure.

Disc shall be cast iron and shall have a rubber seat mounted on disc by retaining plate. The retaining plate with bolt and hinge pin shall be Type 304 stainless steel.

(l) Safety Valves

Safety valves which are used in compressed air or process fluids installations shall comply with BS 6759 Part 2 and 3 or equivalent.

(m) Anti-Vacuum Valves/Devices

Valves and devices with moving parts for the prevention of contamination of water by backflow shall comply with BS 6282 Parts 1-4 or equivalent.

1.4.3 Valve Operators

(a) General

Operators shall be capable of seating, unseating and rigidly holding the valve disc in any intermediate position under the maximum design unbalanced head and water velocity noted.

Means for holding the valves in intermediate positions shall be furnished.

The operating mechanism of butterfly valve, plug valve and ball valve operators shall incorporate worm gears of bronze and worms of hardened steel operating in a lubricating bath totally enclosed in a sealed water tight gear case.

All valves shall be equipped with adjustable mechanical stop-limiting devises to prevent over travel of the valve disc in the open or closed position.

Operator housing, supports and connections to the valve shall be designed with a minimum safety factor of five (5) based on the ultimate strength, or three, based on the yield strength, of the material used.

Extension stem for valves shall be galvanized seamless steel pipe Schedule 80 with pinned coupling.

Support housing for extension stem shall be seamless steel pipe specified above, schedule 40 with reinforcing steel ribs if required.

Each rising-stem shall be provided with stem guard. The stem guard shall be galvanized seamless steel pipe specified above, Schedule 40. The guard shall be of sufficient diameter and length to permit full travel of the threaded stem without obstruction. Top of the guard shall be closed galvanized steel cap.

The stem guides shall be so constructed that when properly spaced they will hold the stem in alignment and yet allow it enough play to permit easy operation.

The guides shall be spaced in accordance with the manufacturer's recommendations for each stem size. The guides shall be adjustable with respect to the bracket to provide proper concentric alignment with the stem, and shall be so designed that alignment will be maintained after adjustment. Brackets shall be attached to the wall by sufficient anchor bolts to prevent twisting or sagging under load.

Each floorstand unit shall be provided with a position indicator to show the position of the valve disc at all times. The indicators of rising-stem floorstand and non-rising-stem floorstand shall be attached to the operator and floorstand respectively. The indicator shall read in percent (0 – 100%) with minimum graduation of 5%.

Manual operator shall require an input force of not greater than 178 N pull on either hand wheel or crank. Hand wheels shall be of cast iron, clearly marked with an arrow and the word "open" and "close" cast in relief on the rim. Hand wheel shall be of the spoke type only. Webbed or disc type shall not be used.

Pedestal shall be of cast iron with sufficient section to withstand the full load encountered in the valve operation, maintaining the safety factor specified.

Manually operated buried valves shall be operated by "T" wrenches, from ground level. Two (2) "T"shall be provided with each standard size of operating unit.

Buried butterfly operators shall be of the totally enclosed worm and gear type. They shall have stainless steel input shafts and special seats to prevent corrosion. They shall be rated at leak tightness, Class IP68 or they shall be totally sealed, immersion proof type approved. The worm and gear unit shall be permanently lubricated with grease. A stem nut shall be provided on the input shaft and it shall have a cap to center the valve box used to guide the entrance and location of the operating wrench.

All gate valves buried in the ground shall be provided with suitable heavy pattern valve boxes of proper dimensions to fit over the valve bonnets and to extend to such elevation, at or slightly above the finished ground surface, as directed by the

Engineer. The barrel shall be not less than the diameter shown. The upper section shall have a flange at the bottom having sufficient bearing area to prevent settling and shall be completed with covers and shall be adjustable. A cap shall center and guide the entrance and location of the operating wrench.

All operators, whose pipe center line is less than 2.0 meters above the operating level shall be of the hand wheel type, unless noted otherwise.

All operators, whose pipe center line is more than 2.0 meters above the operating level, shall be of the chain operated type with chain sufficiently long to reach to 0.9 meters above the operating level, unless noted otherwise.

(b) Manual Operators

(i) Manual Operators for Gate Valves

Manual operators for gate valves, 500 mm and smaller including resilient-seated gates, NRS type shall be wrench nuts and hand wheels type without gear ratio. OS&Y rising stem type resilient-seated gate valves shall be equipped with hand wheels without gear ratio. Wrench nuts and hand wheels shall be made of cast iron or ductile cast iron. The wrench nut shall be 35 mm square at the base with taper 1 to 20 on each side to top of nut, and 63 mm high. The outside diameter of hand wheels shall be not less than those given in the following Table.

VALVE NOMINAL DIAMETER (mm)	**MINIMUM OUTSIDE DIAMETER OF HAND WHEEL (mm)**
50	180
80	180
100	220
125	220
150	220
200	300
250	380
300	380
350	450
400	500
450	530
500	600

(ii) Manual Operators for Butterfly Valves and Ball Valves

Manual operators for butterfly valves and ball valves shall be essentially an integral part of a butterfly valve. The rated torque capability of each operator shall be sufficient to seat, unseat, and rigidly hold in any intermediate position the valve disc it controls under the maximum operating condition. All valves shall be equipped with an adjustable mechanical stop-limiting devices to prevent over-travel of the valve disc or ball in the open and closed positions. Operator housings, supports, and

connections to the valve shall be designed with a minimum safety factor of five (5), based on the ultimate strength, or three (3), based on the yield strength, of materials used.

Each manual operator shall have all gearing totally enclosed. Operators shall be designed to produce the required operating torque with a maximum rim pull of 356 N on handwheel or chainwheel operators and a maximum input of 203 N. m on operating wrench nuts. Stop-limiting devices shall be provided in the operators for the open and closed positions. All operator components between the input and these stops shall be designed to withstand, without damage, a rim pull of 890 N for handwheel or chainwheel operators and an input torque of 406 N. m for operating wrench nuts.

All gears operators shall be self-locking and designed to transmit two (2) times the required operator torque without damage to the faces of the gear teeth. Each manual operator shall be equipped with a position indicator which shall read both in percent (0 – 100%) with minimum graduation of 5% and in degrees (0 – 90 degrees) with minimum graduation of 5 degrees. The graduation shall be engraved on operator cover plate.

(iii) Gearing

Gears shall be of ductile iron, steel, or bronze, accurately machines with cut teeth, and smooth running with suitable shafts in bronze sleeve bearings or roller bearings of ample size.

All gears and bearings shall be enclosed in a cast-iron housing. Fittings shall be provided so that all gears and bearings can be periodically lubricated. For remotely operated valves, the operator shall be supplied with a cast-iron pedestal, machined and drilling to receive the gear housing and drilled for bolting to the operating floor.

(c) Electric Valve Operators

(i) General

Two (2) types of electric valve operators such as Type A, integral control type and Type B, standard type shall be specified hereinafter.

Each type electric valve operator shall be furnished in weather-proof construction. The motor shall operate on 415 volt, 3-phase, 50 Hertz, service for open-close and throttling service.

Each type electric valve, operator shall be mounted by the valve manufacturer, tested and adjusted prior to shipment. All electric valve operators shall be designed and manufactured in accordance with AWWA C540 and shall be Limitorque SMB type or other type approved by the Engineer.

<u>Type A Integral Control Type</u>

Electric valve operator, Type A shall be integral control type and shall include, but not be limited to, the electric motor, reversing magnetic starter, limit switches, torque switches, space heaters, valve position potentiometer if specified, push-

button station, shop wiring, gear case and a declutch hand wheel to allow manual operation of the valve.

The valve control units shall have pushbutton stations furnished in enclosures suitable for flush panel mounting or field mounting as required. The stations shall include pushbuttons, status lights, and a selector switch all as required.

Type B Standard Type

Electric valve operator, Type B shall be standard type and include, but not be limited to, the electric motor, reversing magnetic starter, limit switches, torque switches, space heaters, valve position potentiometer if specified, shop wiring, gear case and a declutch hand wheel to allow manual operation of the valve.

(ii) Electric Valve Operators for Butterfly Valve and Plug Valve

Gear Case shall be of cast iron. Flanges for motor attachment and pedestal attachment shall be integrally cast, fully machine and template drilled.

Motors for electric valve operator shall be capable of producing not less than 1.5 times the required operator torque.

Any gearing in direct association with the electric motor shall be totally enclosed and shall operate in a lubricant.

Operator shall include an adjustable torque or thrust-limited switch capable of stopping the power to the motor when the valve has reached the stops in the open or closed position or when an obstruction has been encountered in either direction of travel. Torque switches shall be factory set to satisfy the calculated value corresponding to the maximum operating conditions.

Limit switches shall be geared to the drive mechanism and in step at all times whether the unit is operated electrically or manually. The switches shall be of the adjustable type capable of being set to trip at the fully open or fully closed valve positions or at any point between. All electrical inter-connections between limit switches, torque switches, indicator lights, and so forth, shall be factory-wired and ready for operation. All gearing used in connection with limit switches shall be factory-lubricated. Operator shall be provided with a position indicator to show the position of the valve at all times. The indicator shall read in percent (0 – 100%) with minimum graduation of 5%.

Operator shall be equipped with a handwheel for manual operation. The hand wheel shall be connected so that operation of the motor will not cause the handwheel to rotate and the operation of the handwheel shall not cause the motor rotor to rotate. The handwheel shall be engaged by an exterior lever or an automatic clutch. The action of the lever shall also declutch the motor if there is no device to accomplish this automatically when the power supply to the motor ceases. Should the power return to the motor while the handwheel is in use, the design of the unit shall prevent the power from being transmitted to the handwheel. The handwheel shall require a maximum 356 N on the rim at any point through valve travel seating or unseating load.

An arrow and the word “open” and “close” shall be placed on the handwheel to indicate direction of resultant valve movement. Lettering shall be in the English language.

(d) Strainers and Sight Glasses

(i) General

The following strainers and sight glasses shall be specified hereinafter:

(a) U-type strainers
(b) Y-type strainers
(c) Sight glasses.

(ii) U-Type Strainers

U-type strainers shall be quick open-and-close type strainers. Strainers shall consist of body, removable body cover plate, mesh cage and yoke with bolt. Strainers shall be constructed so that mesh cage shall be readily accessible, removable, and replaceable without use of special tools and removing the strainer from the line. Removable body cover plate shall have air vent plug and be fixed to the body by means of yoke and bolt. Body shall have drain plug. Mesh cage shall consist of inner mesh cage and outer perforated metal cage. Unless otherwise specified, inner mesh size shall be 40. Mesh cage diameter and length shall conform to the following Table. The strainers shall have flanged ends, and working pressure shall be 0.98 MPa for nominal size 50 mm and smaller and 0.735 MPa for nominal size 65 mm to 150 mm.

NOMINAL SIZE (mm)	**MINIMUM MESH CAGE DIAMETER (mm)**	**MINIMUM MESH CAGE LENGTH (mm)**
15	20	50
20	30	75
25	40	85
32	45	90
40	50	100
50	60	120
65	100	160
80	100	160
100	130	200
125	170	260
150	220	320

Unless otherwise specified, body, cover plate and yoke with bolt mesh case shall be Type 316 stainless steel and stainless steel casting. If specified, body, cover plate and yoke with bolt shall be type 304 stainless steel and stainless steel casting or cast-iron, and mesh cage shall be Type 304 stainless steel.

(iii) Y-Type Strainers

Y-type strainer shall consist of body, removable body cover plate, mesh cage. Strainers shall be constructed so that mesh cage shall be readily accessible, removable, and replaceable without use of special tools and removing the strainer from the line. Removable body cover plate shall be screwed type for nominal size 50 mm and smaller and flanged type for nominal size 65 mm to 200 mm. Mesh cage shall consist of inner mesh cage and outer perforated metal cage. Unless otherwise specified, inner mesh size shall be 40. Mesh cage diameter and length shall conform to the following Table. The strainer shall have flanged ends and working pressure shall be 1.568 MPa.

NOMINAL SIZE (mm)	MINIMUM MESH CAGE DIAMETER (mm)	MINIMUM MESH CAGE LENGTH (mm)
15	18	45
20	23	50
25	30	60
32	39	70
40	44	75
50	56	90
65	78	120
80	88	150
100	110	180
125	140	200
150	170	240
200	210	300

Unless otherwise specified, body, cover plate and mesh cage shall be Type 316 stainless steel and stainless steel casting. If specified, body and cover plate shall be Type 304 stainless steel and stainless steel casting or cast-iron, and mesh cage shall be Type 304 stainless steel.

(iv) Sight Glasses

Sight glasses shall consist of flanged body and two sight glasses with glass holders. If specified, sight glass shall have colored plastic balls. Working pressure shall be 0.98 MPa.

Body for chemical service and for general purpose shall be Type 316 and 304 stainless steel casting respectively.

1.5 Sluice Gates/Penstocks

(a) General

Penstocks shall be of robust design and construction and capable of resisting deflection under the worst operating head conditions.

Penstocks shall be of cast iron or fabricated stainless steel construction. Where applicable the penstock shall be electrically actuated. The direction of closing of the penstock shall be clockwise and the handwheel shall have the direction of closing cast thereon. Bituminous paints shall not be applied to the handwheel.

Penstocks spindles specified to be key operated shall be fitted with stem caps in accordance with BS 5163 table 5 or equivalent.

The penstocks shall be supplied complete with all accessories, fittings, fixing bolts, nuts and washers ready for installation.

The penstocks shall be wall or channel mounted full frame "Flush Invert" type suitable for extended operation.

They shall offer excellent corrosion resistance, be lightweight in operation and require minimum maintenance.

The doors shall be designed for ON or OFF seating pressures and the seals shall not permit a rate of leakage greater than 15 litres per hour per metre of door perimeter at a head not less than 1 m above the maximum head likely to occur.

(b) Pressure Seals

The unseating sides of the frames shall be fitted with adjustable pressure seals. The seals shall be readily adjustable in situ using adjustable stainless steel fasteners which are replaceable. The seals shall not project into the flow through the penstoek aperture.

(c) Drive Spindle and Nut

Penstocks shall be of the rising spindle type with the lifting bracket securely bolted to the top of the door with stainless steel fasteners. The spindles shall be manufactured from stainless steel and the operating nut shall be a non-ferrous material gunmetal or manganese bronze. Polyethylene or similar materials are not permitted.

The rising spindle shall be protected by a protection tube complete with position indicator end cap and grease nipple. Where the spindle length exceeds 2.5m, guide brackets shall be provided for the drive spindle and bushed with aluminium bronze or similar non ferrous material. These shall be of the split bearing type.

(d) Fixing Bolts

The penstock frame shall be fixed by stainless steel anchor bolts or encapsulated epoxy resin bonded type. The design of anchor bolts shall be such that a minimum of civil preparation will be necessary for satisfactory erection of works.

(e) Headstock Pillar

Fabricated mild steel or cast iron pillars shall be provided for the mounting of the drive gear on each of the penstocks supplied under this Contract. The steelwork shall be painted in accordance with the SECTION 1.10 PAINTING AND PROTECTIVE COATING.

(f) Stainless Steel Penstocks

(i) Penstock Frame Construction

The penstock frame shall be fabricated from 316 stainless steel sections. All welds shall be continuous and adequate drainage of hollow sections shall be provided where applicable.

(ii) Door Construction

The penstock door shall be stainless steel sandwich construction. The door shall be stiffened by a steel matrix in a chemically bonded filler of rigid cellular polymer. The matrix shall be grit blasted before polymer filling. Both outer faces of the door shall be protected with stainless steel sheeting.

The door shall have sufficient strength to withstand the working pressures without significant deflection or distortion.

1.6 Measuring Equipment

1.6.1 Pressure and Vacuum Gauges

(a) General

Bourdon tube pressure and vacuum gauges shall comply with PSI 780 or equivalent and the units of measurement shall be metres head of water pressure. Installation shall comply with BS 6739 with adequate line isolation, venting and rodding facilities.

Pressure and vacuum gauges shall have a minimum nominal size of 100mm and full range scale shall be chosen to accommodate the maximum value of the plant parameter with normal operating point selected at 60% of the full scale range. All gauges or switches shall be fully accessible for viewing, maintenance and calibration.

Characters shall not be less than 3mm in height, and due regard shall be given to the maximum distance at which the label must be read and the ambient lighting conditions.

Process connections for pressure measurement shall be configured to allow the venting and rodding out of a blocked process tapping without the removal of the associated pipework and valves.

Steel process pipework which has an associated process connection shall incorporate a purpose made welded boss to BS 2971 or equivalent through which the tapped hole shall be cut. The boss shall be drilled and tapped after welding. BSP threads shall be used as a standard and all threaded connections shall be made with jointing tape. The process tapping shall utilize ¼" BSP threads.

All pressure gauges and switches shall be provided with process isolation by means of a primary isolation valve which shall conform with the following requirements: brass 3, position 3, port "T" configuration full bore ball valve, 3/8" BSPP female

threads. Stainless steel valves shall be utilized where the chlorine residual is greater than 1.0 ppm.

(b) Tubing and Fittings

The selection of the materials for all tubing and fittings shall be determined by the nature of the process fluid and the installation environment but shall be copper, nylon, UPVC or stainless steel. Where mechanically possible, the longest length of continuous tubing shall be to ensure that joints are kept to a minimum. Joints shall be staggered for easier access.

All fittings for use with copper and nylon tubing shall be of brass compression single olive type.

Pressure gauges and pressure switches which are subject to pulsating pressures shall be liquid filled and fitted with adjustable pressure snubbers. The use of needle valves for this purpose shall not be permitted.

1.6.2 Mechanical Water Meter

Water meters, which will be installed in a horizontal steel pipe, shall be of the Woltman dry dial type, with rotary vane or turbine, magnetic coupling and waterproof encased gear trains and register. The inlet and outlet shall have a common axis suitable for water up to 40 °C.

The bodies of bulk water meters shall be manufactured from best quality cast iron with integrally cast flanges PN16, designed for a maximum internal pressure of P=16bar.

This type of water meter shall be flange ended, of the helical type and shall have a registration dial with six-digit integrator calibrated to read in cubic meters and shall be of the straight reading type. The meter shall have a cover plate and a bank lid to be fitted in place of the lid fixed to the metering mechanism, in case the later is removed for repair.

Registration shall be in cubic metres. For ease and accuracy of calibration and adjustment, dials shall register so as to permit accurate readings of 0.05 % of the nominal maximum discharge. Dial covers shall provide an airtight seal. They shall be provided with a non-translucent (not painted) lid, which shall be recessed and shall overlap the registration box to protect the lens.

Registers shall have a minimum capacity of 106 cubic metres for sizes 80 and 100 mm and 100 * 106 cubic metres for sizes above.

The water meter shall be suitable for a 16 bar pressure unless otherwise stated in detail specification and the Contractor shall supply the tapers and the necessary flanges required for the proper completion of the Work. The length of the pipes connected to and from the water meter shall be at least ten times the diameter of each pipe away from fittings or valves.

Markings shall be provided on the meters such as an arrow indicating direction of flow, nominal size, type, year of manufacture and manufacturer's name.

The Contractor shall submit performance data to include head losses and minimum operating head to obtain the required accuracy. Also the Contractor shall fill in the respective data sheet where specified.

The Contractor shall supply install and operate these type of flow meters to measure the flow in water mains. The nominal working pressure of these flow meter types shall be as specified.

1.6.3 Flap Flow Meter

The meter shall be suitable for air and potable water.

- The meter shall have the following application:
- Spring loaded
- Horizontal and vertical flow direction
- Low-pressure loss
- Mainly viscosity independent
- Optional threshold value contacts
- Optional analog outlet 4-20mA

The meter works mainly viscosity- independent magnetic coupling, which shall be protected against tearing off, transmits the movement to an external display once, it is calibrated according to the specification and shall have a measuring substance-specific scale. A semi-circular plate is mounted on a swiveling axis situated in the 50mm thick ring. Depending on flow amount, the angle between the flap and the ring and the display.

Material Specification:

Ring cast iron	1.4571DN 65-100
Steel	1.4571DN 25-600
Display Unit	Steel 1.4301
Technical Data	
Measuring accuracy	5%
Scale in ph: units	
Protection class	IP 65
Sure face protection	Epoxy resin burned in
Temperature	50°C
Pressure	PN 10

1.6.4 Water Level Controller/ Indicator

Water level controller shall be hydrostatic precise sensor 0-1 bar, 4-20 mA, 18-28VDC, accuracy tolerance <1%, work shop fixed cable in one length with vent hose, fixed inside the collector with uPVC protection pipe including connection box wall-mounted IP67 connected to the MCC to control the pump. The level shall be indicated in the instrument panel.

1.7 Chlorination

1.7.1 General

Each installation shall be designed and installed to ensure safety, and without any risks to health of operators. Equipment to be installed in hazardous areas shall comply with the specialist manufacturer's design for this purpose.

The requirements of this Specification apply to new chlorination facilities to be provided under this Contract.

Gaseous Dosing (Chlorination, De-Chlorination and Ammoniation)

Gaseous dosing systems shall comprise pressurized and liquefied gas drums or cylinders complete with automatic changeover equipment, gas feeders and solution injection. All gas dosing systems shall be based upon the full vacuum and remote injection principle.

The safety arrangements for installations handling chlorine in cylinders and drums from 33kg to 1.1 Tonne capacity shall comply with the manufacturer's guidelines and recommendations.

Site installation and commissioning teams shall be properly trained with training which should include both 'off the job' and 'on the job' aspects. An emergency procedure shall include how gas releases may be dealt with safely by site installation and commissioning teams.

1.7.2 Chlorinators

The chlorinators shall be of standard manufacture and shall incorporate pressure reducing valve, safety valve, rotameter, chlorine regulating valve, vacuum regulating valve, vacuum breaker, injector, water supply pressure gauge, chlorine gas pressure gauge and chlorine control valve. The chlorine gas control system shall operate under vacuum and upon loss of vacuum the gas supply shall positively shut off. A vacuum pressure regulating valve shall control the vacuum across the gas metering device so that accuracy of feed will be within plus or minus four percent (+or- 4%) of the indicated flow rate, regardless of varying distribution system vacuum, ejector back pressure or gas pressure. The chlorinator shall be equipped with one (1) dry 'a' contact to transmit a signal of chlorine feeding status to the control monitoring panel. The dry 'a' contact shall be activated close when the chlorine is fed and open when the chlorine is stopped.

All components of the chlorinator shall be materials resistant to chlorine and moisture corrosion.

In addition, where automatic operation is specified chlorinators shall be capable of proportioning the chlorine feed rate automatically in step with variations utilizing 4-20 mA control signals from flow meters and/or chlorine residual analyzers. In this event a chlorine gas feed rate over a 10:1 flow range with metering accuracy of plus or minus 4% of the indicated gas flow rate is required.

1.7.3 Gas Storage

Depending on the gas consumption liquefied gas shall be stored in either cylinders or drums as specified in the contract. Drum stores shall be provided with automatic drum isolation valves, runway beams and hoist mounted weighing equipment together with purpose designed drum lifting beam.

All storerooms must be constructed of fire resistant materials and shall be secure from unauthorized persons, sealed from outside so that in the event of a gas leak, chlorine gas will not flow out of the store room. Drums shall be stored in a position where they are not vulnerable to fire or heat radiation from an adjacent fire.

Equipment for weighing suspended chlorine drums shall be of the hydrostatic load cell type with a circular scale indicator.

Weighers shall be designed for suspension from the load hook of a crane or hoist.

Weighers shall be suitable for operation with a safe working load of not less than 2 tonnes. The indicator scale shall be calibrated in 50 kg divisions, with the zero at the top of the scale and the pointer vertical with no load. The pointer shall incorporate means of tare adjustments up to 1 tonne. The indicator dial shall be not less than 500 mm diameter and slanted from the vertical plane so as to minimize parallax errors when the indicator is read from the floor with the unit hoisted to a high level. Weighers shall have an overall accuracy of better than 1.5% of the full scale deflection and units shall be unaffected by temperature variations in the range minus 10 to plus 45°C.

1.7.4 Chlorine Drums

(a) The drums shall be designed, manufactured, inspected and tested by the manufacturer of the drums. The contractor shall submit hydraulic tests and radiography test records of drums or certificate issued by concerned authority to the Engineer.

(b) Construction and Materials

One-ton chlorine drums shall be designed to contain the specified quantity of liquid chlorine. The drum shall have a cylindrical shell with convex or concave heads and with two identical valves near the centre of one head. The drum shall be fabricated from mild steel having a minimum tensile strength of 41 kg/mm^2. The wall thickness of the drum shall be a minimum of 12mm. Screw threads for fitting of the valves and fusible plugs shall conform to JIS B 8246 or equivalent approved by the Engineer.

After manufacture each drum shall be subjected to radiographic examination by X-ray of longitudinal and circumferential seam welds, junction of welds, and repair of welds.

(c) Marking

The following items shall be marked on the bottom end of each drum in a plain and permanent manner.

(i) Name or mark of the manufacturer
(ii) Name of gas (Cl_2)
(iii) Identification mark and serial number
(iv) Water capacity (Symbol V, unit in liters)
(v) Weight without valves, fusible plugs and protection cap (Symbol W, unit in kg)
(vi) Date of hydraulic test
(vii) Hydraulic test pressure (Symbol TP, unit in kg/cm^2)
(viii) Thickness of cylinder shell of container (Symbol t, unit in mm)

1.7.5 Chlorine Drum Support Rollers

Drum installation shall be complete with drum rollers for drums in use, storage and empty.

1.7.6 Cylinder Clamps

The multiple cylinder racks shall be provided with positive restraint clamps. These clamps shall be either profile clamps or chain restraints which prevent movement of the cylinders from the stored position.

1.7.7 Process piping and valves

(a) Dry and liquid chlorine gas piping

Dry and liquid chlorine gas piping shall be carbon steel piping confirming to BS 1387. Fittings shall be suitable type for high pressure gas service.

(b) Chlorine solution Diffusers

Chlorine solution diffusers shall be of steel pipes lined and covered with rubber. The lining shall be suitable for carrying high concentrated chlorine solution. The rubber lining shall cover all surfaces of the pipe, flanges and bolt holes and orifices.

The lining shall be capable of developing a rubber to metal bond of at least 56 kg/cm^2 and shall have a tensile strength between 168 and 281 kg/cm^2. Minimum lining thickness shall be 4.5 mm but the contractor in all cases shall be governed by the manufacturer's recommendations.

Flanges for rubber lined pipes shall be of the slip on type. Fittings may be of the rubber lined cast iron, flanged type. Gaskets to be used for rubber lined pipes shall be 3.0 mm thick when the flanges are bolted together.

All pipes to be rubber lined shall be new and straight, free from undue roughness on the inside, porosity, grease and oil. Rust and scale shall be removed by shot blasting before the lining is applied. The use of any filter or cement is strictly prohibited. All rubber lining shall be inspected visually and spark tested by the manufacturer using a test apparatus.

(c) Valves for Chlorine Services

Valves for handling liquid chlorine and high pressure chlorine gas shall be suitable for the service intended complete with all safety features to prevent dangerous leaks.

The body and one-piece bonnet and yoke shall be of carbon forged steel or carbon steel. The valves shall have wide deep stuffing boxes with Teflon packing.

(i) Dampers

Dampers to be used for blower of neutralization system shall be butterfly type suitable for the service specified and shall be made of polyvinyl chloride PVC.

(ii) PVC Globe valve

PVC globe valves to be used for chlorine line shall be flanged angle seat, rising spindle type suitable for regulating flow. O-ring and gland packing shall be made of Viton and Teflon respectively. All other parts which may contact with liquid shall be of polyvinyl chloride, PVC Working pressure shall be 10.0 kg/cm^2.

(iii) Isolation Valve

The valve shall be a two way PTFE taper plug valve suitable for use with dry chlorine, the body shall be of LCB carbon steel and plug of monel metal.

A 3/4" male/male nipple shall be provided on the upstream side of the isolation valve for connection to the gas header pipework system.

Isolation Valve Support

The isolation valves shall be supported in a manner which facilitates adjustment in three planes. In this way the pipework connections adjacent to the valve will be relieved of the weight of the valve and actuator.

The method of support shall be clearly indicated in the bid together with the method of adjustment.

Other Valves

All other valves to be used for the chlorination system shall be as specified under Section Valves and Actuators.

1.7.8 Gas Headers

The Contractor shall provide a suitable manifold and header system to convey gas from the cylinders via the changeover panel to the associated gas feeder.

The pipework shall include flexible connectors, isolating valves, interceptor traps, gas filters and all necessary mild steel pipework.

On drum chlorine systems a combined liquid trap and gas filter shall be provided complete with a self-regulating heater.

Pipework and valves shall be designed and constructed to withstand the pressure and corrosive nature of the gas. Welding if used shall be to the relevant British

Standard or equivalent for pipework conveying corrosive liquids under pressure. Suitable isolating valves and couplings shall be provided to each major item of plant to facilitate removal for maintenance. Pressure testing of the pipework and valves shall be carried out by the Contractor to the approval of the Employer, and shall comply with the relevant British Standard or equivalent.

1.7.9 Changeover Panel

The Contractor shall supply an automatic changeover panel which will change from duty gas supply to standby in the event of low pressure on the duty supply. The changeover panel shall include duty/standby indication, bottle or drum change required, and the pressure of gas in the duty cylinder or drum.

The changeover panel shall be mechanically operated and be complete with pressure reducing valves to prevent re-liquefaction of the gas and changeover valve block heater. The line between the changeover panel and the gas feeder shall incorporate individual failsafe vacuum gas regulator valves.

Pressure gauges for use with chlorine shall be of the Bourdon tube type with a special diaphragm isolating the tube from the liquid or gaseous chlorine. Pressure gauges shall have dials not less than 150 mm diameter except where they form an integral part of equipment such as a chlorinator. No aluminium shall be used in the construction of the gauges and the dials and bezels shall be of bronze. Internal components of the gauge and the protector diaphragm housing shall be made of materials resistant to corrosion by chlorine and filled with a proprietary anti-corrosive fluid.

Where necessary, pressure gauges shall be fitted with adjustable electrical contacts for initiation of alarm conditions with either rising or falling pressures.

1.7.10 Chlorine gas neutralization unit

The chlorine gas neutralization unit shall use caustic soda as the neutralizing agent. It will consist of a washing tower, storage tank for caustic soda, induce blower and circulation pump. The material for storage tank shall be of fiberglass-reinforced plastic (FRP) or steel with rubber/PVC lining which is safe from corrosion and heat generation. The pump shall be of stainless steel or FRP or PVC that is safe from corrosion. The blower shall be of stainless steel or PVC or FRP product having a strong suction power.

The leaked gas is automatically sent to the neutralization unit by the blower when a chlorine gas leak detector is energized.

1.7.11 Warning and Safety Notices

The Contractor shall provide and fix engraved Traffolyte labels with Green lettering 20mm high on a Red background. Externally mounted labels shall be provided with a stainless steel back plate for added support

(a) External to the gas store.
WARNING:
CHLORINE STORE

CAUTION ON ENTRY

1.7.12 First Aid Advice

At each new chlorination installation the Contractor shall provide first aid advice displayed as detailed below, together with a resuscitation placard on chlorine gas installations.

First Aid - Chlorine

SPEED IS ESSENTIAL - ACT FAST

Chlorine is toxic and highly irritating gas immediately affecting the eyes, nose, throat and chest. Anyone so affected must be removed to fresh air and medical treatment sought.

EMERGENCY TREATMENT

(1) Call the ambulance; nearest telephone is
(2) If breathing is weak or has ceased, attempt to revive by resuscitation, combined with the administration of oxygen.
(3) Make the casualty comfortable; prop him up in a reclining position.
(4) Loosen the clothing around the neck and chest.
(5) Try to keep the casualty calm
(6) If the casualty's skin or eyes are affected, drench the affected parts with water.
(7) If the casualty's clothing is contaminated it should be removed."
All notices shall be both in English, Sinhalese and Tamil.

1.7.13 Ventilation

Drum stores, bottle stores and Chlorinator rooms, will be sealed from outside environment.

1.7.14 Proportional Gas Feed Systems

Chlorine shall be dosed via duty/standby gas feeders, of the all vacuum/remote ejector principle.

The gas feeder shall dose gas automatically in proportion to flow, chlorine levels, super or residual whichever may be applicable.

1.7.15 Gas Feeder

Gas feeders shall be wall mounted and located such that access for maintenance is unobstructed.

The gas feeder shall incorporate the following features:

(a) Positive Gas Shut Off- in the event of loss of vacuum, gas shall be prevented from entering the system.

(b) High Level Vent - in the event of gas vent, gas shall be directed to a high level external non-hazardous area,
(c) Vacuum Gauge - indicating system vacuum state.
(d) Flowmeter - indicating as flow thorough feeder.

1.7.16 Motive Water

Motive water pumps shall be multi-stage, stainless steel, ring construction and provided on a duty/standby basis. Pumps shall be provided complete with isolation valves, reflux valves and delivery pressure gauges.

In the case of pipelines less than 600 mm diameter, the injector tube shall extend two thirds of the pipeline diameter into the fluid stream. For larger pipelines, the injector tube shall extend right across the pipe bore and be supported with ends located in diametrically opposite flanged branches.

The injector tube shall be drilled at predetermined centres to ensure uniform distribution across the flow profile.

The injection fittings shall be installed in flanged branches with their axis making an angle of 45 degrees with the horizontal in a plane normal to the direction of flow within the pipeline.

Withdrawable type injection fittings shall be used in applications upto 600 mm diameter pipelines.

Injection fittings shall be adequately supported and designed to withstand the flow velocity at the point of application and any flow or turbulence induced vibrations.

The injectors shall operate on the venturi principle to create a local loss of pressure at the throat of the device less atmospheric. The injector shall also mix the chlorine gas with water for feeding.

Each injector shall be made of cast iron or fabricated from steel pipe and shall have lining, rubber lining, PVC lining or others, suitable for wet chlorine gas and chlorine solution. Each injector shall be equipped with a positive seating gas check valve and shall have flanged ends.

Where chlorine solution is to be dosed into flow in open channels and tanks, it shall be applied using an injector diffuser device designed for the specified duty flow rate.

1.7.17 Dosing Control

Where specified, microprocessor based process controllers shall provide automatic control, changeover monitoring and transmission facilities for disinfection control. The unit shall not be susceptible to memory corruption during normal electrical supply transients and shall be protected by a stabilized power supply.

The unit shall provide a continuous display of the actual chlorine residual and also indicate set residual parameters on demand. A separate readout shall also be provided to give operational data including alarm settings etc.

Each unit shall be provided complete with its own residual signal transmitter.

An integral printer shall provide the following status data on its respective system, on demand or at pre set intervals.

(a) Date
(b) Time
(c) Residual chlorine levels
(d) Water Flow
(e) Gas Flow
(f) Alarm Conditions (high and low residual)

In addition a 4-20 mA analogue signal shall be provided to drive a pen of a three pen recorder (the two other pens being driven from the two other controllers associated with its respective pumping system). The pen recorder shall be a 7 day circular recorder and each pen shall be arranged to operate at different radii despite having similar residual chlorine levels. The recorder shall be wall mounted adjacent to the chlorination equipment.

1.7.18 Analyser Cells

Where specified each sampling point shall be selected by the Contractor who shall include in his supply individual analyser cells. This unit shall be supplied with buffer pump and container together with pressure switch and sample/by pass facilities.

The filter shall be mounted outside the unit in a convenient location and in a way which does not require dismantling of the access cover.

Sufficient buffer solution shall be provided for preliminary testing and tests before completion.

The system shall provide for triple validation of the analyser cells and supply lines.

1.7.19 Gas Leak Detection Equipment

Where specified, drum stores, bottle stores and chlorinator rooms shall be provided with a gas sensing alarm system.

Chlorine leak detectors shall be of the bi-metallic cell amperometric type. The leak detectors shall have an alarm levels of 5 μ and 15 μl/l of chlorine gas in the atmosphere to detect any significant leakage from chlorine plant such as chlorinators and chlorine drums.

The units shall be sufficiently sensitive to detect increases in the concentration of 0.1μl/l at a concentration level in the range upto 5 - 15 μl/l

The detectors shall incorporate relays providing volt-free contacts to initiate alarms in the alarm annunciator.

The units shall incorporate test buttons on the front panels facilitating quick cheeks of satisfactory operation of the electronic circuits. These circuits shall include input mains filters and high noise rejection components to afford protection from transients and to make the units suitable for industrial environments.

Each store/room shall be provided with sensors mounted in positions to achieve maximum effectiveness with Chlorine sensors mounted at a low level. Each access door to stores or rooms shall be provided with warning lamps to permit or prohibit entry. A green lamp shall indicate that it is safe to enter, at leak levels below the 3.0 µg/l threshold. A red lamp shall indicate that a 1st or 2nd stage leak has been detected. Each lamp box colour shall be provided with a minimum of two lamps so that a single lamp failure does not render the indication inoperative.

Each building containing a store or room shall be provided with an external flashing/rotating beacon coloured RED and an audible warning device. The audible device shall produce an output of 106dB (A) at 1 metre and shall remain sounding until such time as the alarm is accepted/cancelled, and it shall self-cancel after 5 minutes. The flashing/rotating beacon shall remain operational whilst a 1st or 2nd stage leak persists.

The location of the external flashing/rotating beacon shall be such that it is readily visible to persons entering the site via the main access route.

The works chlorine containers (drums), for the storage and transit of chlorine, the fittings, tools and the like shall be compatible with those available from suppliers within Sri Lanka and shall comply with the relevant statutory requirements. Each drum shall have a nominal capacity of 950 kg of liquid chlorine available above 1 bar pressure. All lifting appliances, drum rollers, auxiliary valves and concrete cradles shall be designed for compatibility with these drums.

1.7.20 Initial Chlorine Charge

The Contractor shall obtain from the local suppliers the initial full charge of liquid chlorine for all containers placed in operational works stores or chlorinator rooms.

1.7.21 Safety Equipment

(a) Emergency Tool Kit

Unless otherwise specified in the Particular Specification, two sets of emergency tool kits and instructions for emergency treatment of chlorine containers shall be provided for each installation in accordance with the recommendations of the manufacturer.

(b) Compressed Air Breathing Apparatus

Each set of compressed air breathing apparatus shall provide complete respiratory protection independent of the surrounding toxic or oxygen deficient atmosphere for 35 minutes calculated in accordance with BS 4667: Part 2, depending on the degree

of exertion. The unit shall combine total reliability with a full degree of mobility to facilitate unhindered emergency rescue or maintenance work.

Each set of apparatus shall comprise a cylinder, pressure reducing valve, demand valve, positive pressure panoramic vision face mask, by-pass valve, harness and waist strap made from rot proof material. The apparatus shall incorporate a warning whistle in the pressure gauge line to indicate approaching exhaustion of the cylinder. The air used to charge the cylinder shall meet the requirements of BS 4275.

Each set of apparatus shall include and be capable of accepting an additional face mask complete with its own demand valve and supply hose in an emergency.

Each set of apparatus shall be supplied complete with two spare cylinders, tools, test gauge kit and accessories all of which shall be housed in a wall mounted cabinet.

(c) Protective Clothing

Each set protective clothing shall comprise overalls, gloves and boots suitable use in the event of a chlorine leak.

The overalls should have PVC coating on both sides and seams shall be welded or glued to provide an adequate seal.

The gloves and boots shall be natural rubber and the boots shall have protective toe caps.

One set shall be housed in a wall mounted glass fronted cabinet provided by the Contractor in a location outside each chlorinator room.

(d) Respirators

Respirators shall be of the canister type and shall have a gas tight full face mask. The canister shall be capable of being supported on the chest or the back by a harness. Each respirator shall be supplied with charts for logging the use of canisters.

The respirators shall be housed in a wall mounted cabinet provided by the Contractor in a location outside each chlorinator room.

1.8 Chemical Dosing

1.8.1 Chemical Dosing Pumps

(a) General

All dosing pumps shall be defined by the duty requirements but in general shall be positive displacement plunger or piston diaphragm pumps. It shall be the Contractors' responsibility to ensure that the pump materials, seals, diaphragm etc. are suitable for the selected application. A reference confirming the ability of the pump to perform the duty shall be submitted with the bid for approval by the Employer.

To help reduce the effects of reduced accuracy and repeatability from the use of the diaphragm pumps, in critical cases automatic closed loop control shall be utilised. This shall be defined further later herein.

The pump design and materials shall be entirely compatible with the chemical to be pumped, with special regard to the following chemical properties:

Corrosive nature	Abrasiveness
Viscosity	Ability to generate free gas
Specific Gravity	Volatility

The pump shall be proven for the duty required and shall be capable of a guaranteed performance with the specific chemical to be pumped.

Pump motors shall incorporate an integral reduction gear box drive which shall be totally enclosed in a lubricated oil bath. The gearbox shall incorporate the cams for the plunger or diaphragm drive and shall be provided with oil filling and drain connections and visible oil level indication.

If integral gearboxes are not used, the drive shall be external V-belt. V-belt drives shall provide six standard stroking speeds to be selected manually by changing pulleys and which shall cover a range of pump speeds of not less than 3:1. V-belt drives shall have full guards of the type that allow the belts to be observed without the removal of the guards.

The design and location of metering pump heads shall facilitate easy dismantling for removal of any foreign matter.

Pumps and drives shall be mounted on a common bedplate.

(b) Diaphragm Pumps

Diaphragm pumps shall have thermoplastic diaphragms faced with polypropylene, butyl or polytetrafluoroethylene (PTFE). The diaphragm shall have at least a two year life at duty point, and shall be designed so that basic maintenance may be carried out with ease.

In the event of a diaphragm failure, the chemical shall be contained within the pump-head, shall not be able to contaminate the gearbox, or the environment local to the pump head.

The following shall be provided:

- A diaphragm failure sensor, which shall be capable of being utilised in a control system, and of generating an alarm both locally and to telemetry.
- An automatic gas release system, linked to the suction tank, capable of maintaining prime at all times irrespective of the gassing properties of the chemical.
- Integral dry suction protection system.
- Manual over-ride of automatic control equipment.

– Wetted componentry which shall be entirely compatible with the process chemical.

The pump head shall be manufactured from a solid billet or moulding of material, shall contain facilities for the connection of gas release pipework (to be connected if required), and the tappings for the suction and delivery ball valves.

For viscous chemicals and slurries special attention shall be paid to ball return characteristics and facilities for fitting return springs shall be available. Double ball valves shall be utilised where the manufacturer's experience dictates that reliability will be enhanced.

(i) Low Flow Applications

Wherever possible, dosing pump shall be powered by solenoid drive or by electronically controlled motor drives where the controlling electronics are self contained within the pump body.

The pumps shall be capable of reliable operation at stroke ranges from 10 - 100% with maximum accuracy between 30 - 90% stroke at better than + 3%, and shall be capable of operating with diaphragm frequencies from between 5% to 100% of range without causing thermal distress to the drive.

(ii) Mid and High Flow applications

Pumps shall be driven by A.C. electric motors (in compliance with Specifications for motors included elsewhere) via an integral gearbox, which shall be totally enclosed, drip-proof and designed with a minimum service factor of 2. The box shall be sealed throughout by mechanical type seals of "O" ring form, shall be designed for a minimum of maintenance, and shall be separated from the pump-head by positive means of protection.

The pumps shall be capable of reliable operation at stroke ranges from 10 - 100% with maximum accuracy between 30 - 90% stroke, and shall be capable of operating with diaphragm frequencies from between 25% to 100% of range without causing thermal distress to the drive.

The pump shall exhibit better than + 2% accuracy and repeatability following calibration and shall maintain this performance for a minimum of 5,000 hours.

Where necessary, the pump system shall be designed to accept multiple pump heads driven from a common prime mover via a fully guarded drive extension.

Individual stroke setting shall be possible within this mode.

(c) Plunger Pumps

Plunger material and pump head shall be compatible with the media pumped and shall have alumina type ceramic or stainless steel plungers as a minimum standard. Pump heads shall be either stainless steel or polypropylene. Mechanical glands shall not be used.

The output of the pump shall be adjustable by varying the effective length of the displacement stroke. Variable stroke mechanisms shall be incorporated which enable the pump output to be varied manually, locally while the pump is running, by means of a micrometer handwheel or similar device.

The plunger gland shall incorporate multi-chevron seals, capable of sustained contact with the dosed chemical and resistant to any abrasive qualities present in the fluid.

Double ball valves shall be incorporated in both the suction and delivery lines, to enhance volumetric efficiency.

The pump shall be capable of +1.5% accuracy and repeatability following calibration, and shall sustain this performance for a minimum of 5,000 hours running.

1.8.2 Slurry Dosing

All dosing pipework shall be compatible for use with slurry and sized to maintain a minimum velocity of 2 m/s. Abrupt changes of section shall also be avoided in order to prevent precipitation. On all rigid pipework union couplings shall be used throughout, particularly at tees and bends where rodding points shall be provided.

All valves used on the slurry pipework system shall be full bore (weirless) diaphragm type. Pinch valves may be used on the delivery side of the pump but shall not be used in the suction lines. Diaphragm material shall be natural rubber.

1.8.3 Dosing System Design Requirements

All essential dosing components or systems shall have 100% standby, capable of automatic selection on failure of the duty unit. Unless otherwise specified, each point of application shall be served by either a rigid pipe or a flexible hose and all hoses and pipes shall be connected to the pump delivery downstream of the last valve. Unless otherwise specified, duplicate standby delivery pipes / hoses are not required, but a spare hose for each chemical point of application shall be supplied and kept in store.

The suction conditions shall be ensured by correct design of suction storage vessels, use of generous suction strainers (at least 6 x pipe area and for chemicals only NOT for slurries) from approximately 80 mesh media, and the maintenance of NPSH at a minimum of 2 metres positive at the suction inlet. Flooded suction shall be preferred with a bunded and fully protected pump area.

A calibration vessel shall be fitted, at equal level to the storage vessel, to be determined at site conditions, so that accurate calibration can be executed by site personnel.

Dosing lines shall be sized to satisfy the duty point and adapted to suit the media properties as appropriate and shall be installed in association with any “in-line static mixers’ specified.

All dosing delivery lines shall include pressure relief valves. The PRV shall be sized to carry 10% more than the dosing pump duty flow.

Dosing line surge alleviators/pulsation dampers shall be used on each system.

Loading valves shall be utilised where injection pressure is insufficient. These valves shall also incorporate an anti-vacuum/siphon break feature to prevent "draw down" of chemical in the event of evacuation of the water main being dosed.

Withdrawable injection fittings shall be provided at all chemical dosing points. The fittings shall comprise a non-return valve, injection tube (to ensure dosage at the centre line of the associated main/channel) and an isolating valve. Fitting and removal of the injection fitting shall be possible without isolation of the associated main channel.

The suction line of all dosing pumps shall incorporate manually operated change-over valves which shall permit complete flushing of the suction line, dosing pump and delivery valve. This shall be automatic for lime dosing pumps for automatically controlled treatment works.

Where applicable, bund interiors shall be protected by epoxy resin based coatings capable of easy application to building materials.

1.8.4 Chemical Tanks

Chemical storage tanks and mixing and batching tanks shall be in compliance with the respective chemical contractor's instructions and be high density polyethylene.

Chemical storage tanks shall be suitable for internal and external application and be of the closed top type. They shall be designed to withstand pressures likely to be experienced during remote tanker filling and incorporate bracing, vents, inlet and outlet connections, a low level-drain and manway access points.

The roof vent shall be central, of the mushroom cap type, incorporate bird and vermin guards and be of not less than 150mm in diameter. A 100mm diameter overflow shall be provided at an invert level 300mm below the base of the vent pipe. Where tanks are for internal application, the vent shall be ducted outside the building.

Access ladders in accordance with BS 4211 or equivalent and MES 5 shall be provided for access to the roof of the tanks. Handrailing and platforms shall be in accordance with MES 6. Component materials shall be suitable for the chemical being stored.

Where stirrers are required, in mixing and batching tanks galvanised supports of material suitable for use with the chemical being stored shall be provided separate from the tank structure. Incorporation into bracing is acceptable.

Mixing and solution tanks shall be provided on a duplicate basis as a minimum requirement unless otherwise specified.

Inlet and outlet pipework shall incorporate manually operated isolation the inlet pipe shall be top entry into the tank and incorporate a low level drain routed into the bund drain sump.

Tanks shall be erected on flat foundations. Tanks shall be bunded, the bunds to be capable of containing 110% of the tank volumes including the volume of the tank inside. Bunds shall also be provided with drainage sumps to aid recovery of the chemicals.

Level indication shall be provided by level control equipment mounted on the roof of each storage tank. A 100mm flanged connection shall be provided for level control in each compartment of the tank, where applicable.

Type Test Certificates shall be provided. All equipment shall be subjected to a works test to ensure that it functions correctly, performs and to specification.

Where such certified evidence is not available a Letter of Intent from The Testing Authority shall be submitted.

All equipment shall be visually inspected before installation to ensure that no obvious damage has occurred during transit and storage. Where relevant, ranges, duty, labelling etc. shall also be checked.

All flanged cast iron pipework and fittings shall be subject to a site leakage test. Notwithstanding satisfactory completion of these tests, any leakage visible on the outside faces shall be stopped. Any caulking or making good shall be carried out from the inside face. All of the works shall be demonstrated to have been erected correctly be reliable in operation under conditions at site and be capable to cover its whole working range.

The results of all works and site tests carried out by the Contractor shall be recorded, certified and submitted to the Employer.

1.9 Positive Displacement Pumps

1.9.1 General

Applications excepting chemical dosing pumps generally fall into the following categories:

- Progressive Cavity Pumps
- Ram Pumps
- Peristaltic Pumps
- Diaphragm Pumps
- Rotary Lobe Pumps

1.9.2 Pump Performance

The pump head versus flow characteristic shall be stable and the unit shall be non-overloading.

Where the maximum pump duty is met by parallel pump operation the pumps shall be capable of operation without over loading.

Contractors shall select the most economic pumps given the constraints of the operating parameters and particular requirements of the specification.

1.9.3 Pump Casing

Pump casings shall be high grade cast iron to BS 1452 or equivalent and be abrasion resistant, capable of taking shock loads and incorporate lifting eyes located for removal of the pump.

Suction and delivery branches shall be incorporated in the casing and include tappings for pressure gauges. Drain plugs shall be provided at the lowest point and automatic air release valves complete with isolating cocks and bleed lines, to the bedplate tundish. Flanges shall comply with BS 4772 or equivalent.

1.9.4 Pressure Ratings

Pump casings and discharge pipework up to and including isolation valves and non-return valves shall be rated to a minimum of 16 Bar.

1.9.5 Bearings

(a) Thrust Bearing

Any axial thrust generated shall be taken by a thrust bearing arrangement.

Thrust bearing arrangements incorporated into the motor housing are not permitted without approval of the Employer.

Setting of thrust bearings shall account for dynamic loading albeit setting is carried out with the machinery stationary.

(b) Rolling Element Bearing

Ball or roller bearings shall comply with BS 292 or equivalent and shall be sealed for life. They shall be rated to give minimum life of. 75,000 hours at maximum load without replacement. Bearings shall be protected by water throwers and lip seals,

(c) Plain/Bush Bearings

Bush bearings, where utilized, shall be in bronze or equal, split for easy maintenance and positively locked to prevent rotation.

(d) Bearing Design

Bearings shall be sized to guarantee a service life of 10,000 hours. Bearing housings shall be sealed to prevent ingress of dust and water and shall incorporate splash rings for lubrication.

The bearing housing shall be of the cartridge type to allow removal of the bearing without disturbing the pump.

1.9.6 Sealing

(a) Soft-Packed Gland

Gland packing shall be graphite impregnated PTFE, of approved manufacture. Asbestos based packing will not be permitted.

The gland design shall incorporate the follow;

(1) A tapered “lead in” at the mouth of the gland entry to facilitate packing replacement and obviate the risk of damage on assembly.
(2) The surface finish of the adjacent metal parts shall be 0.4mm CLA on the shaft gland sleeve and 1.6mm CLA on the stuffing box bore.
(3) Where running clearances are excessive, the packing shall be protected by an independent ring of robust material which reduces the clearance to a minimum.
(4) The packing must not be used as a bearing.
(5) All studs, dowels and adjustable nuts shall be manufactured from stainless steel.
(6) Lantern rings shall be of gun metal or bronze and shall be split for ease of removal.
(7) Pumped water supplied to the lantern ring shall be free from abrasive solids.

(b) Mechanical Seals

The Contractor shall specify the type, size and material of the mechanical seal be intends to supply. It shall be the responsibility of the pump manufacturer to ensure that the tolerances required by the seal manufacturer are not exceeded. Checks shall be carried out on the pump casing and shafting for:

(1) Shaft straightness
(2) Rotational Balance
(3) Shaft run-out
(4) Bearing clearance - lateral and radial movement
(5) Shaft tolerance and ovality
(6) Concentricity
(7) Seat squareness
(8) Coupling alignment

The Contractor shall ensure that the seat, face and component materials of the mechanical seal are suitable for the media being sealed. Under operational conditions thermal loading of the seal components shall be within the capacity of seal and wear rate is minimized.

(c) Gland Drainage

Gland drainage shall be collected in a collecting tray formed integrally with the pump casing stuffing box. The tray shall not extend high enough to submerge the gland in the event of drain hole blockages. Drainage shall be piped to the bed plate tundish located at the non-driven end of the pump.

(d) Stuffing Box

The stuffing box shall be manufactured from cast iron of a heavy section independent of the pump body and shall be provided with drain holes.

1.9.7 Pump Shaft

(a) Shaft Sleeves

Where shafts are exposed to the process fluid and where they pass through the sealing gland they shall be fitted with sleeves of bronze or stainless steel, positively driven and which extend through the stuffing box. The finish of the sleeve at the seal faces shall be highly polished (0.4mm CLA).

The diameter of the sleeve shall not be taken into account when calculating shaft stiffness.

(b) Balance

The whole of the rotating assembly. including locking key(s) and pumping element, shall be dynamically balanced as an integral component. The pumping element shall also be dynamically balanced separately and then assembled to the shaft, to form without further adjustment, a dynamically balanced whole. Balancing shall be carried out at normal operating speed(s).

1.9.8 Mounting

Pumpsets shall have the pump and motor mounted on a common bedplate of cast iron or fabricated steel which shall incorporate machined reference surface to permit levelling of the assembled pumpset on its foundation, The bedplates shall be fully supported on sets of steel packers and shims which shall not be less than 80mm wide or twice the width of the bedplate frame drilled for positive location by the same. Not more than three packers shall be used.

The pump shall be mounted on and bolted to the bedplate and unless positively located be dowelled in its final position with not less than 0.75mm of brass shimming between the pump and bedplate. The motor shall not be dowelled until after final alignment on site has been checked and approved by the Employer's Representative. Dowel pins shall be Grade A in accordance with BS 1804 Part 3 or equivalent.

1.9.9 Couplings

(a) General

Couplings shall be provided to permit the removal of drive shafts, bearings, etc. without removing the pump or motor. Couplings between the thrust bearing and motor shall be accommodated within motor/support stools.

Couplings shall be of the pin and buffer type unless otherwise specified.

(b) Coupling Alignment

After coupling alignment the Employer shall witness and accept the machine alignments which shall be recorded in accordance with BS 3170 or equivalent.

1.9.10 Rating Plates

Rating plates shall be fitted to all pumps, be manufactured and fixed by corrosion resistant material (excluding brass) and include full details of the pump including size, type, serial number, duty point flow head, speed, NPSH and the closed valve head.

The weight of the pumpset, motor and bedplate or stool shall be marked on the pumpset data plate.

1.9.11 Guarding

All machine enclosures shall be safeguarded in accordance with BS 5304 or equivalent and with guards fixed to either the pumpset bed plate or motor stool whichever is most practical. Couplings shall be totally enclosed.

Shaft guards shall extend the whole length of the shaft and include hinged access doors at lubrication/inspection points for couplings, bearings, sliding joints, etc.

Mesh sizes or apertures in the guard shall not exceed 12mm diameter or 12mm square.

1.9.12 Lifting Brackets

Integral lifting brackets, shackles and lifting eyebolts shall be manufactured from stainless steel with minimum ultimate tensile strength of 540 MN/m2 and certified in accordance with BS 4278 or equivalent. Both bolt and hole shall be permanently marked, preferably by punching, with the diameter and thread form used. All eyebolts shall be of the collar type.

1.9.13 Progressive Cavity Pumps

(a) General

Progressive Cavity Pumps comprising a stator manufactured from a resilient material and a helically ground rotor shall be considered for pumping industrial sewage, sludges or highly abrasive and corrosive products without rags and grit.

(b) Design

Pumps shall be manufactured with a short compact block design with close coupled drive or alternatively foot mounted drive via flexible coupling connection.

The pump shall be restricted to cavitation free operation throughout its rated band of speeds at its duty points.

(c) Stator

Vulcanised synthetic rubber stators shall be manufactured with extended ends to form a collar to prevent twisting of the stator within the pump casing.

Optionally, slotted stators are required for retrofitting with a stator tensioning device to provide even clamping of the stator to rotor to prolong service life.

Suction casings shall be provided with clean-out/inspection ports.

(d) Rotor

Rotor design shall incorporate low wear geometry by providing an elongated pitch, wider sealing line and reduced peripheral velocity of the rotor within the stator thus reducing rotor slip back.

Rotor surfaces shall be ground finish or coated with a minimum 250 micron thickness non porous hard chroming compound diffused into the base material.

(e) Rotating Drives

Drive torque shall be transmitted through two universal joints or flexible shafts. They shall be designed for continuous transmission of the maximum torque at the maximum speed and pressure. Joints shall be designed to enable replacement pins and bushes to be fitted, manufactured from wear resistant steel.

Universal joints shall be protected from damage by the fitting of sleeves with 304 stainless steel guards to prevent ingress of pumped media. Sleeves shall be secured by two holding bands. Joints shall be lubricated with grease to provide a 10,000 hour life guarantee.

Drive shafts shall incorporate a 'plug-in' type design to allow dismantling of drive shaft and seal without dismantling the bearing housing

(f) Overpressure Protection

A device to protect against overpressure shall be fitted and shall take the form of either a pressure relief circuit fitted with an adjustable valve to return flows to the suction of the pump or a pressure switch installed in the delivery port to stop the pump.

(g) Suction/Flow Failure Protection

Suction protection shall take the form of either a thermistor installed in the stator to monitor a rise in temperature caused by friction between rotor and stator or a flow sensing device or, when installed, a low flow inhibit signal from a flowmeter. The systems shall be complete with all necessary instrumentation for free issue to the control panel manufacture.

1.9.14 Peristaltic Pumps

(a) General

Peristaltic pumps shall be considered for sludge, raw sewage and abrasive materials applications.

(b) Design

Peristaltic pumps and associated pipework shall be designed to allow for easy removal of all the component parts especially the hose. Removal of the hose shall not disturb the sliding shoes, pump body or rotor.

The design shall allow for mounting in all 90% vertical planes from a rigid galvanised mild steel bed-plate which supports the pump, gearbox and motor the preferred option is with the suction in the horizontal at the lowest point of the pump and this shall be adhered to unless otherwise specified.

If the acceleration or impulse losses exceed 0.3 bar on the suction of the pump then an inlet port accumulator shall be fitted.

If the application requires a smooth flow characteristic then a pulsation damper shall be fitted to the delivery port.

(c) Rotor

The rotor shall be of lightweight design and construction keyed to the drive shaft.

(d) Sliding Shoes

Two diametrically opposite sliding shoes shall be secured to the rotor. They shall be adjustable to allow for wear.

(e) Bearings

The pump drive shaft and rotor assembly shall be supported upon two main heavy duty ball bearings.

(f) Lubrication

The hose to shoe contact shall be continuously lubricated with an approved lubricant. If this takes the form of a bath then a lubricant level detection system shall be employed to monitor for both lubricant leakage and hose leakage together with an external sight glass to visually monitor the level.

(g) Hose

The hose shall be manufactured to provide at least 1000 hours life at maximum designed speed, temperature and pressure without undue deterioration in pump performance. To prevent a “permanent set” in the hose the control of the pump shall include a timed rotation of the unit at least once per week with an inconsistent rest position.

(h) Suction Protection

A suction blockage shall be detected by a vacuum switch on the suction side and the pump shall reverse for a timed period before resuming normal operation. Controllers shall be “free issued” to the control panel manufacturer upon request

1.9.15 Rotary Lobe Pumps

(a) General

Rotary lobe pumps shall be considered for sludge, raw sewage and non abrasive materials applications.

(b) Design

The design of rotary lobe pumps shall ensure ease of access to and removal of the rotors, seals, wear plates and all maintainable items.

(c) Rotors

Rotors shall be of robust construction manufactured in rubber or urethane covered cast iron.

(d) Body

All wetted parts of the pump head shall be manufactured in ductile iron. 'The front of the pumps shall incorporate an "O" ring seal to provide face to face contact of the cover. The cover shall be manufactured in hardened steel to allow for future grinding of the worn surface.

(e) Wear Plates

Wear plates shall be employed between the rotors and the internal body to prevent direct side contact with the pump body. They shall be manufactured from hardened steel.

(f) Suction Protection

A suction blockage shall be detected by a vacuum switch on the suction side to stop the pump. The switch shall provide both normally open and normally closed contacts for cabling to the control panel.

(g) Delivery Protection

A delivery blockage shall be detected by a pressure switch on the delivery side to stop the pump. The switch shall provide both normally open and normally closed contacts for cabling to the control panel

1.9.16 Diaphragm Pumps

(a) General

Diaphragm pumps shall be considered for sludge and raw sewage with high fibre content and where there is a possibility of prolonged dry running but shall be limited to solids handling of 25mm spheroids.

Only double disc pumps without glands and valves are considered appropriate for these applications.

(b) Design

The design of the units shall allow the free passage of solids, grit and rags. The replacement of expendable components such as the diaphragms shall be easily manageable.

(c) Diaphragms

Diaphragms shall be manufactured from Nitrile, Viton or EDPM as the process dictates. The life of diaphragms shall be 1000 working hours at maximum design pressures and temperatures.

(d) Bearings

Bearings shall be designed to provide maintenance free operation throughout the life of the pump unit. Should the pump have to operate under arduous conditions, such as constant high head, then the bearings shall be fitted with nipples for periodical regreasing.

(e) Installation

Due to the pulsating action of these pumps the surrounding pipework shall be rigidly bolted to foundations or support structures to avoid vibration and a flexible coupling shall be provided between the pump and associated pipework. A pulsation damper with an integrally sealed air cushion arrangement shall be provided on the discharge pipework.

(f) Suction-Protection

A suction blockage shall be detected by a vacuum switch on the suction side to stop the pump. The switch shall provide both normally open and normally closed contacts for cabling to the control panel.

(g) Delivery Protection

A delivery blockage shall be detected by a pressure switch on the delivery side to stop the pump. The switch shall provide both normally open and normally closed contacts for cabling to the control panel.

(h) Covers

For units installed externally in areas where ambient temperatures fall below -5°C for more than 2 consecutive days in the year then insulated GRP covers shall be provided with thermostatically controlled heaters to ensure frost protection of the pump and associated equipment.

1.10 Painting and Protective Coatings

1.10.1 General

(a) Surfaces to be painted.

In general, the following surfaces are to be painted.

(i) All exposed piping and other metal surfaces, interior and exterior.
(ii) All submerged metal surfaces.
(iii) All structural and miscellaneous steel, including tanks.
(iv) The interior of tank and pits as specified in the painting schedule and as required after equipment installation.

(v) The interior of structures as specified in the painting schedule and shown on the plans as required after equipment installation.
(vi) Equipment furnished with and without factory finished surfaces, except as specified below.
(vii) All interior and exterior exposed surfaces of buildings, and exterior exposed surfaces of the water towers and reservoirs

(b) Surfaces not to be painted

The following surfaces in general shall not be painted.

(i) Concrete surfaces subject to pedestrian traffic.
(ii) Plastic Surfaces.
(iii) Non-ferrous metal unless otherwise noted or indicated. (Galvanised metal shall not be considered a non-ferrous metal).
(iv) Mechanical Equipment with approved factory finish as specified herein.
(v) Electrical equipment with approved factory finish as specified herein.
(vi) Piping which is specified as galvanised.

In no case shall any concrete, wood, metal or any other surface requiring protection be left unpainted even though not specifically defined herein.

(c) Submittals

Materials specifications, surface preparation and application instructions, and colour sample cards shall be submitted to the Engineer for approval.

(d) Paint to be Provided to Employer

The Contractor shall leave on the job site at the conclusion of the Contract a minimum of four (4) litres of each type and colour of finish paint used on the work. Each container shall be properly labelled for identification.

1.10.2 Materials

All paint materials shall be first quality products manufactured for the exposures involved, as approved by the Engineer. Paints which are to be in contact with water or chemical solutions shall be completely inert and free of lead and other toxic substances.

(a) System A Material

Primer	:	Zinc-rich epoxy primer.
Intermediate	:	Universal type primer
Finish	:	Vinyl acrylic finish

(b) System A1 Materials:

Primer	:	Etching primer
First Coat	:	Red lead primer or lead suboxide primer
2nd Coat	:	Long oil alkyd resin paint

3rd Coat	:	Long oil alkyd resin paint
Finish	:	Long oil alkyd resin paint

(c) System B Materials:

Primer	:	Epoxy primer
Intermediate	:	Polyester epoxy enamel
Finish	:	Same as intermediate

(d) System B1 Materials:

Primer	:	Organic zinc rich primer
First Coat	:	Organic zinc rich primer
2nd Coat	:	Chlorinated rubber paint
3rd Coat	:	Chlorinated rubber middle coat
Finish	:	Chlorinated rubber finish coat

(e) System C Materials:

Primer	:	Zinc-rich epoxy primer
Intermediate	:	Epoxy polyamide coaching conforming to Steel Structures Painting Cou Paint 16-68T.
Finish	:	Same as intermediate.

(f) System C1 Materials:

Primer	:	Inorganic zinc rich primer
First Coat	:	Epoxy primer
2nd Coat	:	Epoxy primer
3rd Coat	:	Poly-urethane resin paint
Finish	:	Poly-urethane resin paint.

(g) System D Materials:

Primer	:	Vinyl-based cementitious block filter.
Intermediate	:	Vinyl acrylic emulsion, F.S.TT-P-19.
Finish	:	Same as intermediate.

(h) System D1 Materials:

Primer	:	Epoxy resin.
Intermediate	:	Epoxy resin.
Finish	:	Epoxy resin.

System D1, epoxy resin pain system shall be suitable for drinking water service and paint shall be certified by recognized public health authorities for linings in potable water. The Contractor shall submit certification of paint which is suitable for drinking water service.

(i) System D2 Materials:

Primer	:	Inorganic zinc rich primer
First Coat	:	Epoxy primer
2nd Coat	:	Epoxy primer
3rd Coat	:	Epoxy resin paint
Finish	:	Epoxy resin paint.

(j) System E Materials

Tnemec Seroes 66 Hi-Build Epoxyline System or approval equal.

Primer	:	Epoxy polyamide masonry filler or coating
Intermediate	:	Epoxy polyamide coating.
Finish	:	Same as intermediate.

(k) System E1 Materials:

First coat	:	Tar epoxy resin paint
2nd coat	:	Tar epoxy resin paint
3rd coat	:	Tar epoxy resin paint

System E1, tar epoxy resin paint system shall be suitable for drinking water service and paint shall be certified by recognised public health authorities for linings in potable water. The Contractor shall submit certification of paint which is suitable for drinking water service.

(l) System E2 Materials:

Primer	:	Organic zinc rich primer
First coat	:	Tar epoxy resin paint
2nd coat	:	Tar epoxy resin paint
3rd coat	:	Tar epoxy resin paint

(m) System F Materials:

Primer	:	Latex base, F.S. TT-P-645.
Intermediate	:	Latex flat, F.S. TT-P-29
Finish	:	Same as intermediate.

(n) System F1:

System F, paint system for galvanized surfaces shall be:

(i) Surface preparation and primer

Surface shall be free from moisture, dust or other contaminants with use of solvent cleaning. Damaged galvanized area shall be cleaned by using hand or power tool, and surface shall be finished as SSPC-SP3. All galvanized surface and surface cleansed shall be painted with etching primer, minimum dry film thickness of 20 microns.

(ii) Coat

After finishing surface preparation, painting system A1, B1, C1, D1, D2, E1 or E2 shall be applied unless otherwise specified.

(o) System G Materials:

Primer	:	Pigmented oil primer, F.S. TT-S.179.
Intermediate	:	Enamel under coat, F.S.TT-E-543.
Finish	:	Semi-gloss enamel, S.S. TT-E-508.

(p) System H Materials:

Primer	:	Exterior wood primer, F.S. TT-P-25.
Intermediate	:	Exterior gloss, F.S. TT-E-489.
Finish	:	Same as intermediate.

(q) System I Materials:

Primer	:	for ferrous metal, red lead primer, F.S.TT-P-86. for galvanised, zinc-duct zinc-oxide primer; F.S.-TT-P641.
Intermediate	:	Exterior gloss enamel, F.S.TT-E-489.
Finish	:	Same as intermediate.

1.10.3 Workmanship

(a) Protection of the Work

The Contractor shall take the necessary steps to protect the work of others during the time his work is in progress. The Contractor shall be responsible for any and all damage to the work. Paint shall be applied only during periods of favourable weather.

(b) Preparation of Paint

All materials specified or selected for use under these specifications shall be delivered unopened at the job site in their original containers and shall not be opened until inspected by the Engineer. Paint containers shall be opened only when required for use. Paint shall be thoroughly stirred or agitated to uniformly smooth consistency suitable for proper application. In all cases, paint shall be prepared and handled in a manner to prevent deterioration and inclusion of foreign matter. No paint shall be reduced or applied in anyway except as herein specifically called for or, if not specifically called for, then it shall be applied in accordance with the manufacturer's recommendations.

(c) Preparation of Surfaces

The Contractor shall examine carefully all faces to be finished and before beginning any of his work shall see that the work of the other trades has been left or installed in a workmanlike condition to receive paint. Metals shall be clean, dry, and free from mill scale, rust, grease, and oil.

(d) Workmanship

Each coat of paint shall be applied at the proper consistency and brushed evenly, free of brush marks, sags, runs, with no evidence of poor workmanship. Care shall be exercised to avoid lapping paint on glass or hardware. Paint shall be sharply cut to lines. Finished paint surfaces shall be free from defects or blemishes.

(e) Protective Coverings

Protective coverings or drop cloths shall be used to protect floor, fixtures, and equipment. Care shall be exercised to prevent paint from being spattered onto surfaces which are not to be painted. Surfaces from which such paint cannot be removed satisfactorily shall be painted or repainted, as required to produce a satisfactory finish.

(f) Tints

Whenever two (2) coats of paints are specified, the first coat shall contain sufficient powered aluminium or carbon black to act as an indicator or proper coverage, or the two(2) coatings must be of contrasting colour.

(g) Brushing

All paint shall be applied by brush unless otherwise specifically approved by the Engineer.

(h) Instructions

All coatings shall be performed by personnel experienced in the application of said coating systems and in accordance with the manufacturer's printed instructions. The final appearance shall exhibit a uniformly textured and coloured coating free of excessive gloss or dull spots, blemishes, sags, runs, pinholes, and other defects.

(i) Ventilation

The Contractor shall not permit painting to begin in enclosed places, until a forced draft ventilation system of sufficient air volume has been placed in operation.

(j) Right of Rejection

No exterior painting or interior finishing shall be done under conditions which may jeopardise the appearance or quality of the painting or finishing in any way. The Engineer shall have the right to reject all material or work that is unsatisfactory, and require the replacement of either or both at the expense of the Contractor.

1.10.4 Application of Painting System:

(a) System A

Un-galvanized ferrous metal subject to corrosive moisture or atmosphere and condensation.

i) Surface Preparation: All metal surfaces shall be field sandblasted in accordance with Steel Structures Painting Council Specification SSPC-SP-10

(Near-White Blast Cleaning). Weld surface, edges, and sharp corners shall be ground to a curve and all weld splatter removed.

ii) Coating: Prime coat shall have a minimum thickness of 0.05 mm. An intermediate coat shall have a minimum thickness of 0.05 mm. and finish coat shall have a minimum thickness of 0.1 mm. The total system shall have a minimum dry film thickness of 0.2 mm.

iii) Time between Coatings: A minimum of 12 hours time is required before additional coats may be applied to the prime coat, two hours for the intermediate coat, and two hours for the finish coat.

(b) System A1

Ungalvanized ferrous metal, outdoor service, except buried, submerged and other surfaces specifically included elsewhere.

Surface Preparation : SSPC-SP-6 or SSPC – SP-3
Coating Thickness :

Item		**Minimum Dry Film Thickness (mm)**
Primer	:	0.02
First coat	:	0.035 each
2nd and 3rd coat	:	0.035 each
Finish coat	:	0.035
Total	:	0.160

(c) System B

Ungalvanised ferrous metals not subject to chemical attack, normal indoor exposure, except as specified otherwise.

i) Surface Preparation: All surfaces shall be freed of dirt, dust, grease, or other foreign matter before coating. Surfaces shall be cleansed in accordance with the Steel Structures Paint Council Specification SSPC - SP-7 (Brush-off Blast Cleaning). Weld surfaces and rough edges shall be ground and weld splatter removed.

ii) Application shall be in strict conformance with the manufacturer's recommendations. All sharp edges, nuts, bolts, or other items difficult to coat shall receive a brush-applied coat of the specified coating prior to application of each coat.

iii) Coating System: The system shall have a minimum total dry film thickness of 0.1 mm resulting from a prime coat and at least two finish coats.

(d) System B1

Ungalvanised ferrous metal, indoor service, except special areas specified, buried, submerged and other surfaces specifically included elsewhere.

Surface Preparation : SSPC-SP-6 or SSPC – SP-3
Coating Thickness :

Item		Minimum Dry Film Thickness (mm)
Primer & First coat	:	0.02 each
2nd and 3rd coat	:	0.04
Finish coat	:	0.035 each
Total	:	0.15

(e) System C

Ungalvanised ferrous metal submerged or intermittently submerged in water or corrosive liquid.

i) Surface Preparation: All metal surfaces shall be field sand-blasted in accordance with Steel Structures Painting Council Specification SSPC-SP-10 (Near-White Blast Cleaning). Weld surface, edges, and sharp corners shall be ground to a curve and all weld splatter removed, and welds neutralised with thinner.

ii) Application: Shall be in strict conformance with the manufacturer's recommendations. All sharp edges, nuts, bolts, or other items difficult to coat shall received a brush-applied coat of the specified coating prior to application of each coat.

iii) Coating System: The prime coat shall have a minimum thickness of 0.08 mm and two or more finish coats shall have a minimum total thickness of 0.4 mm. The total system shall have a minimum dry film thickness of 0.48 mm.

(f) System C1

Ungalvanised ferrous metal, outdoor service, specially specified, except buried and submerged

Surface Preparation : SSPC-SP-10
Coating Thickness :

Item		Minimum Dry Film Thickness (mm)
Primer	:	0.75
First coat and 2nd coat	:	0.06 each
3rd coat and Finish coat	:	0.03 each
Total	:	0.255

(g) System D

Exterior or interior brick, concrete, and concrete block work exposed to view not subject to immersion in liquids and not subject to pedestrian traffic except as otherwise specified. Interior surfaces not specifically indicated shall not be painted. All concrete block surfaces to be painted shall be filled with latex type block filler supplied by the paint manufacturer whose products are used prior to first or prime paint coat.

i) Surface Preparation: All surfaces shall be freed of dirt, dust, grease, and other foreign matter before coating. Cracks and voids shall be repaired or filled with a suitable material compatible with the specified paint.

ii) Coating: The first coat shall be applied to cover and provide a smooth base. The finish coat shall be applied to a dry film thickness of 0.04 mm minimum.

iii) Time between Coats: The filler coat may be recoated in 12 hours; the finish coat is dry for a recoat in two hours.

(h) System D1

Ungalvanised ferrous metal submerged.

Surface Preparation : SSPC-SP-10
Coating Thickness :

Item		Minimum Dry Film Thickness (mm)
First	:	0.20
2nd coat	:	0.20
Finish coat	:	0.20
Total	:	0.6

(i) System D2

Ungalvanized ferrous metal, indoor service, corrosive environment.

Surface Preparation : SSPC-SP-10
Coating Thickness :

Item		Minimum Dry Film Thickness (mm)
Primer	:	0.075
1st and 2nd coat	:	0.06 each
3rd and finish coat	:	0.05 each
Total	:	0.295

(j) System E

Concrete subject to intermittent or continuous submergence, unless specified otherwise in other sections of these specifications.

i) Surface Preparation: All surfaces shall be brush-off blasted to remove all dirt, dust, form oil, curing compounds, and other deleterious compounds. In general, the concrete shall be reasonably smooth, and free of pockets and cavities.

ii) Coating System: The prime coat and intermediate and finish coats shall each have a minimum dry film thickness of 0.1 mm. The total system shall have a minimum dry film thickness of 0.3 mm.

iii) Time between Coats: All coats shall be applied within 24 hours of the previous coat, or in accordance with the manufacturer's instructions.

(k) System E1

Ungalvanized ferrous metal submerged or intermittently submerged in water potable water production process.

Surface Preparation : SSPC-SP-3 or SP-10
Coating Thickness :

Item		**Minimum Dry Film Thickness (mm)**
First coat	:	0.2
2nd coat	:	0.2
Finish coat	:	0.2
Total	:	0.2

(l) System E2

Ungalvanized ferrous metal, submerged or intermittently submerged in water, except the potable water production process.

Surface Preparation : SSPC—SP-3 of SP-10
Coating Thickness :

(m) System F

Interior concrete, masonry and plaster surfaces scheduled or directed to have a flat finish. Concrete block masonry surfaces shall be given a coat of block filler according to system D prior to painting.

Preparation, Coating, and Time: As specified for System D.

(n) System G

Interior concrete, masonry, and plaster scheduled to have an enamel finish. Concrete block masonry surfaces shall be given a coat of block filler according to System D prior to painting.

i) Surface Preparation: All surfaces shall be freed of dirt, dust, grease, and other foreign matter before coating. Cracks and voids shall repair or filled with a suitable caulking material compatible with the specified paint. Efflorescence shall be neutralised with zinc sulphate solution and allowed to dry.
ii) Coating:The prime coat shall be applied to cover and provide a smooth base. The undercoat and finish coat shall be applied to a total dry film thickness of 0.075 mm minimum.
iii) Time between Coats: Each coat shall be completely dry before the next coat is applied.

(o) System H

Interior and exterior wood.

i) Surface Preparation: Unless already properly hand sanded, sandpaper smooth by hand and dust clean. Neatly fill nail holes, cracks and depressions therein with approved filler, coloured to match required finish; when dry, sandpaper and smooth.
ii) Coatings: Prime coat shall be applied to cocker and provide a smooth base. Each finish coat shall be applied to a minimum dry film thickness of 0.05 m.
iii) Time between Coats: As specified for System G.

(p) System I

For interior and exterior metal not painted under System A, B, and C.

i) Surface Preparation: For ferrous metal, as specified for system B. Wash galvanised surfaces with solvent thinner.
ii) Coatings: Apply each coat to a minimum dry film thickness of 0.05 mm.
iii) Time between Coats: As specified for System G.

1.11 Metal and Metal Fabrication

The Contractor shall provide all labour, materials, equipment and incidentals necessary to furnish and install structural steelwork required to erect the structural framing.

1.11.1 Detailing

The Contractor shall submit complete sets of detailed working and shop drawings and schedules of all structural steelwork in accordance with the Conditions of Contract.

The Contractor shall furnish a mill certified report, in triplicate, of the tests for each lot of steel from which the material is to be fabricated. The certification shall contain the results of chemical and physical tests required by the specification for the material. In the event the results of any test are not in conformance with the requirements of these Specifications, the Engineer reserves the right to make additional mill and laboratory tests. When additional tests are required, the Contractor shall furnish, cut and machine additional test specimens in accordance with British Standard requirements. The additional costs of furnishing, cutting and machining additional test specimens shall be borne by the Contractor.

Shop drawings shall show any field welding necessary for the assembly or erection of the steelwork.

1.11.2 Materials

(a) Steel

All Structural Steel shall, comply with the mechanical and chemical composition and other requirements of the latest editions of relevant following Standards and grades including the following specified.

Structure shapes, plates and bars unless otherwise noted	Hot-rolled Section and Plates. BS 4360: "Weldable Structural Steel" Grade 43A. **or** ASTM A36 "Structural Steel
Corrosion resistant structural shapes, plates and bars	ASTM A242, "High Strength Low-Alloy Structural Steel"
Square steel columns	Hot-rolled Hollow Sections. BS 4360: "Weldable Structural Steel: Grade 43C. **or** AISI C1015
Round Tube. BS 1775: "Steel tubes for Mechanical, Structural and General Engineering Purposes" Grade 16 or BS 4360 Grade 43C. Lipped C section purlins. Australian Standard (AS 1397) Hot dipped zinc coated G 450 - Z 275 (450 N/mm^2 Minimum yield stress and 275 g/mm^2 minimum coating mass)	BS 639, AWS Spec. for Arc Welding Rods
Cold Rolled Section BS 1449 Part 1: "Carbon Steel plate, sheet and strip". Minimum yield strength Shall be 250 N/mm^2,	
Steel pipe (medium weight)	BS 1387,"Steel Tubes and Tubular Suitable for Screwing to BS 21 Pipe Threads"

Ductile iron High strength steel bolts	ASTM A536 (grade 60-40-18) ASTM A325, "High Strength Bolts for Structural Steel Joints"	
Structural steel Bars and shapes	ASTM A36 "Structural Steel"	
Mild Steel for Railing, posts, Flanges and sleeves (standard strength unless noted otherwise)	ASTM A53 "Welded and Seamless Steep Pipe"	
Cast iron	ASTM A48 (class 30) "Gray Iron Castings"	BS 1452, "Gray Iron Castings"
Bolts and Nuts	ASTM A307 Low Carbon Steel Externally and Internally Threaded Standard Fasteners"	**or,** High-Strength friction grip bolts to BS 4395 or grade 8.8 bolts to BS 3692
Cast Steel	ASTM A27 "Mild-to-Medium-Strength Carbon-Steel Casting for General Application"	
Stainless steel pipe	ASTM A269, type 304 "Seamless and Welded Austenitic Stainless Steel Tubing for General Service"	
Stainless steel plate and sheet	ASTM A480, type 304 "General Requirements for Delivery of Flat-Rolled Stainless and Heat-Resist-ing Steel Plate, Sheet and Strip"	
Stainless steel bars and shapes	ASTM A276, type 304 "Stainless and Heat-Resisting Steel Bars and Shapes"	
Aluminium for Structural Shapes	ASTM B221, alloy 6061, temper T6, "Aluminum-Alloy Extruded Bars, Rods, Shapes, and Tubes"	
Architectural aluminium	ASTM B221, alloy 6063, Temper T5	

Rolled steel	ASTM A283 "Low and Intermediate Tensile Strength Carbon Steel Plates of Structural Quality”

1.11.3 Bolts, Nuts and Washers

(a) All bolts and nuts shall comply with the following British Standards

(b) BS 4190: ISO metric black hexagon bolts, screws and nuts". Strength Grades 4.6

(c) BS 3693: ISO metric black hexagon bolts - Strength Grade 8.8. BS 3692: Nuts and washers.

(d) All plain washers shall comply with BS 4320: "Metal washers for General Engineering purposes" and shall be normal diameter series of normal range thickness.

(e) All spring washers shall comply with BS 4464: "spring washers for General Engineering and Automobile purposes (Metric Series)".

(f) All bolts washers and nuts shall be 'non rust' either black or bright in appearance and shall not be painted.

1.11.4 Workmanship

Unless otherwise specified, structural steel shall be fabricated in accordance with the requirements of the British Specifications for the Design, Fabrication and Erection of Structural Steel for Buildings. All members shall fit closely together and shall be straight and true, and the finished work shall be free from burrs, bends, twists, and open joints.

Workmanship shall be in accordance with Section 1.11.10 "Metal Fabrication".

Materials for welding shall be in accordance with the recommendations of the manufacturer of the material to be welded and in accordance with AWS or British Standards. All holes, angles, supports, and braces shall be provided as required. All field assemblies shall be shop assembled and disassembled prior to shipment. Any unmatched holes in shop assembly of field connections shall be reamed and the pieces match marked before disassembly. Drift pins shall be used only for bringing members into position and not to enlarge or distort holes. Any piece, weakened by reaming to compensate for eccentricity to a point where the strength of the joint is impaired, shall be rejected and a new and satisfactory piece shall be provided by the Contractor. Slotted holes and washers shall be provided for truing up lintels and other steel requiring accurate alignment. During erection, approved temporary bracing shall be installed as required to prevent distortion or damage to the framework due to wind or erection forces.

1.11.5 Field Connections

Field connections shall be made by welding High-Strength friction grip bolts to BS 4395 or Grade 8.8 bolts to BS 3692.

1.11.6 Welding

Welding shall be in accordance with Section 1.11.10 "Metal Fabrication".

The Contractor may substitute field bolting where field welding is shown, provided bolting details showing shop drawing have been approved.

1.11.7 Bolting

Bolts shall conform to BS 4190 or BS 3693 "Sets of High Strength Hexagon Bolts, Hexagon Nuts and Plain Washers for Friction Grip Joints".

Anchor bolts shall be of mild steel with hexagonal nuts. Threads shall be clean cut and conform to ANSI, B1.1, "Unified Screw Threads" coarse thread UNC, Class 3A or British Standards.

Anchor bolts shall be accurately set before the concrete is poured unless specifically permitted otherwise by the Engineer. To facilitate the setting of anchor bolts, the Contractor shall utilise screed plates. The Contractor may substitute wooden templates in lieu of screed plates upon written approval by the Engineer.

Anchor bolts with pipe sleeves shall be as specified.

Bolt anchors shall be of the cinch, awl or slug-in type. Anchors shall be minimum two unit type.

All bolt, nut and washers, threads shall be hot dip galvanised and shall conform to British Standards, ANSI B1.1, Class 2A 0.

1.11.8 Painting

(a) Shop Painting

All structural steel shall be given shop primer after fabrication and cleaning but before shipping.

All steel work shall be thoroughly cleaned of all loose mill scale, rust, and foreign matter before shop painting. Each individual piece shall be painted prior to assembly. Edges where field welding is required shall not be painted.

Paint shall be applied only to dry surfaces.

(b) Field Painting

After erection the Contractor shall thoroughly prepare and clean the entire surface of all structural steel of all dirt, grease, rust or other foreign matter. The entire surface of all members shall be field painted as specified in SECTION 1.10 “PAINTING AND PROTECTIVE COATING".

1.11.9 Miscellaneous Metals

(a) Scope of Work

The Contractor shall furnish all labour, materials, equipment and incidentals necessary to supply and install all miscellaneous metals, concrete anchors and ornamental iron required.

(b) Shop Drawings

The Contractor shall prepare shop drawings for all work mentioned in this Specification. All such shop drawings shall be approved by the Engineer before the work commences.

Every drawing shall be AI Size show the number and sizes of all rivets and bolts, complete details of welds, type of electrodes, welding procedure including where the welds are to be made, and any other relevant information.

Shop drawings shall show size, welding details, thickness and gauge of all materials and all installation details. Field dimensions shall be specifically noted on the shop drawings.

Unless otherwise approved in writing by the Engineer, the Contractor shall furnish a mill certified report, in triplicate, of the tests for each material to be utilised in the work. The certification shall contain the results of chemical and physical tests required by the Specifications for the materials.

The Contractor shall submit three (3) samples of all materials to be supplied under this Section for approval, unless otherwise approved in writing by the Engineer.

(c) Co-ordination

The Contractor shall completely co-ordinate the work of this section with other contracts. The Contractor shall verify, at the site, both the dimensions and work of other contractors which adjoin his materials before installation of items herein specified. Field measurements shall be taken at the site and incorporated in the shop drawings.

The Contractor shall furnish all necessary templates and patterns required by other sections. He shall also furnish to the pertinent contractor, all items included this section that are to be built into the work of other contractor, and shall supervise and be responsible for the proper location and installation of such.

(d) Fabrication

All miscellaneous metal work shall be formed true to detail, with clean, straight, sharply defined profiles, and smooth surfaces of uniform colour and texture and free from defects impairing strength or durability.

Connections and accessories shall be of sufficient strength to safely withstand stresses and strains to which they will be subjected. Accessories and connections to steel or cast iron shall be steel, unless otherwise specified. Threaded connections shall be made so that the threads are concealed by fitting.

Welded joints shall be rigid and continuously welded or spot welded. The face of welds shall be dressed flush and ground smooth. Exposed joints shall be close fitting and jointed where least conspicuous. Pipe railing panels shall be straight and true to dimensions. Adjacent railing panels shall align with a variation not to exceed 1.5 mm. Joints shall be match marked.

(e) Finishes

All steel work shall be thoroughly cleaned, by effective means, of all loose mill scale, rust, grease and foreign matter and shall be given one shop coat of paint after fabrication but before shipping. Shop painting shall be in accordance with the requirements specified in SECTION 1.10 “PAINTING AND PROTECTIVE COATING”. Paint shall be applied to dry surfaces and shall be thoroughly and evenly spread and well worked into joints and open spaces. Abrasions in field erection shall be touched up with primer immediately after erection.

Galvanised surfaces shall not be painted, unless noted otherwise.

Casting shall receive a coat of coal-tar pitch varnish before shipments. The varnish shall present a smooth finish and shall be tough but not brittle.

Cadmium coatings and chromium coatings shall conform to Section 1.1.11.10 "METAL FABRICATION".

Galvanising shall conform to Section 1.1.11.12 "GALVANIZING".

All aluminium exposed surfaces shall have satin finish, free from die markings, scratches, welding discoloration, "leave-off-marks", or other surface blemishes. Unless otherwise specified, aluminium shall be given an Anodic oxide treatment in accordance with the Aluminum Association Specification AA-C22-A31. Aluminium, which after installation, will be exposed to severe corrosive conditions or wearing, shall have a finish equal to the Aluminum Association Specification AA-C22-A41. A coating of methacrylate lacquer shall be applied to all aluminium before shipment from the factory.

All exposed stainless steel surfaces shall be polished finish, free from die markings, welding discolorations or other surface blemishes.

(f) Installation

The Contractor shall install all items furnished including items to be embedded in concrete or masonry.

Items, to be attached to concrete or masonry after such work is completed, shall be installed in accordance with the details shown. Fastening to wood plugs in concrete or masonry will not be permitted. The Contractor may use plastic or fibre covered lead inserts.

All aluminium surfaces to come in contact with concrete or masonry shall receive a heavy protective coating of bituminous applied in a neat manner. All aluminium surfaces to come in contact with dissimilar metals shall receive a heavy brush coat

of zinc chromate primer followed by two coats of aluminium paint and a fabric separator. The dissimilar metal surface shall receive two coats of masonry paint.

(g) Bolts and Nuts

Unfinished bolts shall have hexagonal heads and hexagonal nuts. The bolts shall be long enough to extend entirely through the nut but not more than four (4) threads beyond. Washers under nuts shall be furnished.

Threads for all nuts and bolts shall comply with ANSI B1.1, "Unified Screw Threads", coarse thread, UNC class 3A.

Anchor bolts, with or without pipe sleeves, shall be in accordance with the details shown and include washers and hexagonal nuts.

Galvanised bolts shall be of the hot dip galvanised type.

Screw and bolt anchors, that are not shown, shall be cinch anchors, awl or of the slug-in type. Anchors shall be minimum "two unit" type. Toggle bolts shall be of the size indicated and shall be galvanised.

Bolt and nut threads shall be galvanised and shall conform to BS 729, ANSI B1-1, Class 2A.

(h) Nails and Spikes

Nails and spikes shall be of the proper type, of new wire of adequate size and number to securely fasten and hold members in place. Samples of concrete masonry nails shall be submitted to the Engineer for approval and shall be of the corrugated or split type. Cut nails will not be accepted for masonry nails.

(i) Miscellaneous Shapes

Miscellaneous shapes shall include but not be limited to sump cover plates, floor plates, angles, beams, fabricated plates, channels, bars and metal anchors for embedment in concrete or masonry.

Miscellaneous shapes shall be mild steel, unless stated otherwise. All material shall be in accordance with the details shown or specified.

(j) Hand Railings

Hand railings indicated to be steel pipe shall be constructed pipe conforming to BS1387 "Steel Tubes and Tubulars Suitable for Screwing to BS21 Pipe Threads" Medium class.

Railings shall be constructed of 38 mm pipe unless otherwise indicated and shall be galvanized. Joints shall be welded in conformance with the details shown except railings required to be galvanised shall have galvanised socket joints.

Railings shall be of the two rail or one rail type with vertical posts or wall anchorage. Vertical posts shall be provided every one (1) meter.

Where steel toe boards are used, they shall be 10 cm. high of 4 mm thick steel plate attached to the railing posts by means of clips to prevent movement. Toe boards shall be continuous.

Fasteners for joining rails will only be permitted at removable sections, expansion joints, or as indicated.

Railing posts may be set in boxed out sleeves, or pipe sleeves. Posts shall be grouted in using cement mortar and a steel cover plate. Galvanised chains shall be installed across openings in railings where indicated. One end of each chain shall be provided with a hook and eye for attachment purposes.

Chain links shall be 6 mm wide with twelve links per 30 cm.

Removable pipe railing shall be provided where shown and as detailed.

(k) Gratings

All gratings shall be welded rectangular opening type, galvanised flat bar gratings with seat angles, anchors and supports of galvanised steel. All gratings up to and including 1 meter shall be furnished in pieces approximately 1.0 m in width and all gratings for spans greater than 1.0 m shall be furnished in pieces approximately 0.8 m in width. All openings required in gratings shall be cut after fabrication but before galvanising. Gratings shall be banded where openings are provided and shall be strengthened as necessary. Installed units shall be true to plane and free of warpage and irregularities. Units shall be divided for ease of installation and removal, using the following minimum size to span ratios.

Maximum Span	**Bolts (mm at @ m)**	**Seat Angles (mm)**	**Shelf Angles (mm)**
0.9	12 at @ 1.2	25 x 25 x 5	50 x 50 x 6
1.2	12 at @ 1.1	40 x 40 x 6	50 x 50 x 6
1.5	12 at @ 0.9	50 x 50 x 6	50 x 50 x 6
1.8	12 at @ 0.7	75 x 50 x 8	50 x 50 x 6
1.95	12 at @ 0.6	65 x 50 x 8	50 x 50 x 6
2.1	16 at @ 0.6	50 x 50 x 6	50 x 50 x 6
2.4	16 at @ 0.6	60 x 60 x 10	60 x 60 x 6

(l) Safety Steps

Safety steps shall be cast iron or ductile iron unless otherwise specified. All safety steps shall be hot dip galvanised unless it is of stainless steel. The surface of all safety steps shall be of the non-slip type. The step section shall be a minimum of 15 cm from the vertical surface.

Each safety step shall be manufactured to safely hold a weight equal to 450 kilograms, when embedded in masonry or concrete. The top step shall be placed no more than 15 cm from the top surface and the lowest step shall be placed a maximum of 30 cm from the bottom surface.

Step bar shall be installed every 30 cm interval vertically on centre in concrete and masonry; and shall not be subjected to any loads for a minimum of seven (7) days after placement.

(m) Cast Iron Frames and Covers

Cast iron frames and covers shall conform to AISC specifications for the Design, Fabrication and Erection of structural steel for Buildings. Section 1.11.10 "Metal Fabrication"; conform to the details shown or the manufacturer's recommendation, and be furnished and set by the Contractor. Frames with flanges shall have equally spaced side braces. All covers and grates shall have two (2) lift holes located 180 degrees apart, unless noted otherwise. Frames, covers and grate seats shall be machined to a true plane surface and shall seat firmly without rocking.

Covers required to be locked shall be provided with locking devices which will secure the covers to the frame and which will only be operated by a special wrench or similar device. Covers required to be watertight shall be similar to those required to be locked and in addition a round rubber gasket shall be provided for the cover seat. Covers required to be hinged shall be provided with the necessary hinges.

Covers shall have letters cast in. Unless shown otherwise, all lettering shall be in English. The Contractor shall receive approval of shop drawings by the Engineer prior to casting.

All small parts, bolts and erection fasteners shall be included.

(n) Bar Screens

Bar screens shall be fabricated as detailed of non-corrosive aluminium alloy or stainless steel. Spacing of screen bars shall be as shown.

Guides shall be of the same material as the bar screen.

(o) Gates

Steel gates shall be as specified. Locking devices for gates shall be as specified. Locks, keys and master keys shall be in accordance with sub-section "Hardware". All materials shall be shop primed and finish painted in accordance with sub-section "Painting".

(p) Steel Hangers for Wood Framing

Steel rafter hangers, gusset plates, and similar devices for wood framing shall be fabricated from gauge steel and galvanised after fabrication and drilling.

(q) Barbed Wire Fencing

Stock proof barbed wire fencing shall conform to BS 1722: part 3.

Barbed wire shall be of mild steel conforming to BS 4102.

1.11.10 Metal Fabrication

(a) Scope of Work

This section specifies the workmanship standards applicable to the various phases of metal work fabrication, the methods and precautions for erection of metal structures and machines to insure conformance with the specifications and miscellaneous requirements incidental to the work.

(b) Workmanship

(i) General

Material shall be thoroughly straightened by methods that will not result in injury, except that sharp kinks or bends in members to be straightened will be a cause for rejection. Finished members shall be free from kinks or bends. Shearing shall be accurately done, and all portions of the work neatly finished. Corners shall be square and true. Where re-entrant cuts cannot be made by shearing, a rectangular punch may be used. Re-entrant cuts shall be filleted, unless otherwise approved by the Engineer, Bends, except for minor details, shall be made by approved dies or bending rolls. Where heating is required, precautions shall be taken to avoid overheating the metal and it shall be allowed to cool in such a manner as not to destroy the original properties of the metal. Steel with welds will not be accepted, except where welding is definitely specified, or otherwise approved. All bolts, nuts, and screws shall be tight. The ends of pipes, except for handrails, shall be reamed.

(ii) Dimensional Tolerances for Structural Work

Dimensions shall be measured by means of an approved calibrated steel tape of the same temperature as the structure at the time of measurement. Unevenness of platework shall not exceed the limitation of standard mill practice as specified in the British Constructional Steelwork Association Ltd. "National Structural Steelwork Specification for Building Construction".

An allowable variation of 1 mm is permissible in the overall length of members with both ends milled, Members without milled ends, which are to be assembled to other steel parts of the structures, shall not deviate from the dimensions by more than 1.8 mm for members 10 meters or less in length, and by not more than 3 mm for members over 10 meters in length.

(iii) Camber

Unless otherwise specified, joists having spans of 12 meters or greater shall have minimum cambers as given in the table at the end of this section. Reverse camber in any joists in excess of 1/1000th of the span shall be a cause for rejection.

(c) Welding

Welding of parts shall be in accordance with the Standard Code for Arc and Gas Welding in Building Construction of the AWS and shall only be done where shown, specified, or permitted by the Engineer. All welding shall be done only by welders certified as to their ability to perform welding in accordance with locally accepted testing requirements. The AWS Code will be used as guide.

Welding of pressure vessels shall be in accordance with the ASME, "Boiler and pressure Vessel Code" or approved equivalent standard.

Welding of steel water pipe shall be in accordance with AWWA C206, "Field Welding of Steel Water Pipe Joints" or BS 2971, "Recommended Practice for Manual Arc Welding (Steel Sheet)", BS EN 180 9692, "Recommended Practice for Submerged Arc Welding (Mild Steel Sheet)" and BS EN 1011, "Recommended Practice for Semi-Automatic Arc Welding", or approved equivalent standard.

Damage to galvanised areas shall be thoroughly cleaned by wire brushing and all traces of welding flux and loose or cracked zinc coating removed prior to painting. The cleaned area shall be painted with two coats of zinc oxide-zinc dust paint conforming to the requirements of American Federal Specification MIL-P-15145. The paint shall be properly compounded with a suitable vehicle in the ration of one part zinc oxide to four parts zinc dust by weight. As an alternate to the above, the Contractor may submit for approval the use of a galvanising rod or galvanising solder to repair damaged areas.

(d) Flame Cutting

Low-carbon structural steel may be cut by machine guide or hand guided torches instead of by shears or saw. Flame cutting of material, other low carbon structural steel, shall be subject to approval and where proposed shall be definitely indicated on shop drawings submitted to the Engineer. Where a torch is mechanically guided, no chipping or grinding will be required except as necessary to remove slag and sharp edges. Where a torch is hand guided, all cuts shall be chipped, ground, or machined to sound metal except where material is to be welded, in which case burrs and rough edges only shall be removed. Where the torch is mechanically guided, flame gauging will be permitted in preparation for welding.

(e) Bolted Connections

(i) Bolt Holes

Holes for unfinished bolts, unless noted otherwise, shall be not more than 1.6 mm larger than the nominal diameter of the bolts. Unless otherwise specified, holes for turned bolts shall be not more than 0.50 mm larger than the nominal diameter of the bolt, Where the thickness of the material is greater than the nominal diameters of the bolt, holes for unfinished bolts shall be sub-punched and reamed or sub-drilled and reamed or drilled from the solid metal. Holes for turned bolts shall be truly cylindrical throughout and drilling or reaming shall be done after the parts to be connected are assembled. Mismatching of holes shall be a cause for rejection.

(ii) Bolts and Nuts

Threads of bolts and nuts shall conform to BS, ANSI, JIS or ISO standards. Bolts and nutsshall conform to the applicable provisions of American Federal Specifications FF-B-575b for "Bolts, Hexagon and Square" and FF-N-836a for "Nut, Plain (Square, hexagon and Cap), Nut Slotted and Castellated, Hexagon" . The finished shank shall be long enough to provide full bearing, and washers shall be used under the nuts to provide full grip when the nuts are tightened.

(iii) Washers

Plain washers shall conform to the requirements of ANSI B27.2, "Plain Washers" heavy series, and lock washers shall conform to the requirements of ANSI B27.1, "Lock Washers" heavy series. Washers shall be provided for applications specified elsewhere. Galvanised washers shall be provided under the bolt head and also the nut in assembling all galvanised parts.

(iv) Special Bolted Connections

Where turned bolts with closer fits than specified above are required, the bolts shall have a nominal body diameter at least 1.6 mm larger than the nominal diameter of the threaded portion and the body length shall be 1.6 mm to 3.2 mm greater than the combined thickness of the connected members. Threads shall be Class 3 fit in accordance with the Federal Specification. Holes shall be as specified. Plain washers shall be provided.

(f) Machine Work

(i) General

All tolerances, allowances and gauges of metal fits of cylindrical parts shall conform to ANSI B4.1 "Preferred Limits and Fits for Cylindrical parts", for the class of fit as shown or otherwise required. In general, tolerances for machine finished surfaces, designated by non decimal dimensions, shall be within 0.4 mm. Sufficient machining stock shall be allowed on placing pads to insure surfaces of solid material. Finished contact or bearing surface shall be true and exact to secure full contact. Journal surfaces shall be polished and all surfaces shall be finished with sufficient smoothness and accuracy to insure proper operation when assembled. Parts entering any machine shall be carefully and accurately machined and all like parts shall be interchangeable. All drilled holes for bolts shall be accurately located.

(ii) Finished surfaces

Where surface finishes are specified herein, the symbols used or finishes specified, are in accordance with ANSI B46.1, "Surface Roughness, Waviness and lay". Values of roughness height specified are arithmetical average deviations expressed in micro inches. Roughness specified is the maximum value and any lesser degree will be satisfactory. Compliance with specified surface will be determined by sense of feel and by visual inspection of the work compared to roughness comparison specimens, in accordance with the provision of ANSI B46.1. Values of roughness width and waviness height are not specified, but shall be consistent with the general type of finish specified by roughness height. Flaws such as scratches, ridges, holes, peaks, cracks or checks which will make the part unsuitable will be cause for rejection.

Where the finish is not indicated or specified, the type of finish shall be that type which is most suitable for the surface to which it applies and shall be consistent with the class of fit required. Surfaces to be machine finished shall be indicated on the shop drawings by symbols which conform to ANSI B46.1.

(iii) Unfinished Surfaces

So far as practicable, all work shall be laid out to secure proper matching of adjoining unfinished surfaces. Where there is a large discrepancy between adjoining unfinished surface, they shall be chipped and ground smooth, or machined, to secure proper alignment, Unfinished surfaces shall be true to the lines and dimensions and shall be chipped or ground free of all projections and rough spots. Depressions or holes not affecting the strength or usefulness of the parts may be filled in a manner approved by the Engineer.

(iv) Pin Holes

Pin holes shall be bored true to gauges, smooth and straight, and at right angles to the axis of the member. The boring shall be done after the member is securely fastened in position.

(v) Gears

All gears shall have machine cut teeth of a form conforming to the applicable AGMA or other standard approved equivalent.

(vi) Shafting

Unless otherwise specified or authorised, all shafting shall be turned or ground steel shafting. Fillets shall be provided where changes in section occur. Cold-finished shafting may be used, where keyseating is the only machine work required.

(vii) Bearings

Bearings may be lined with babbit or bronze. Babbit shall conform to ASTM B23, "White Bearing Alloys" . Where the bearing pressure is in excess of 14 kg/sq. cm, bearings shall be lined with bronze. Unless otherwise required or authorised, pressures on lined bearings shall not exceed 70 kg/sq. cm of projected area. Anti-friction bearings of types and of sizes not less than those recommended by the bearing manufacturer for the duty may be permitted at the discretion of the Engineer. All bearings shall be properly aligned and provided with a suitable means for lubrication. Anti-friction bearings shall be so installed as to provide for lubricant and to exclude dirt and grit.

(viii) Protection of Machined Surfaces

Machine finished surfaces shall be thoroughly cleaned of foreign matter. Finished surfaces of large parts and other surfaces shall be protected with wooden pads or other suitable means. Unassembled pins and bolts shall be oiled and wrapped with moisture resistant paper or protected by other approved means.

Finished surface of ferrous metals which will be exposed after installation shall be painted as specified in SECTION 1.10 "PAINTING AND PROTECTIVE COATING". Corrosion resisting steel, non ferrous metal and galvanised surfaces shall not be painted.

(ix) Lubrication

Before erection or assembly, all bearing surfaces shall be thoroughly cleaned and lubricated with approved lubricant. After assembly, all lubricating systems shall be filled with the lubricant specified, or approved and, as required, additional lubricant shall be applied at regular intervals to maintain the equipment in satisfactory condition until accepted.

(g) Steel Plate and Protection Angles

Steel plate and protection angles required for the protection of concrete work shall be erected true to line and grade with the tolerances specified below. The edges of exposed faces may have a vertical or horizontal distortion from a straight line not greater than 3 mm per meter of length, provided, that distortion for any single piece shall not exceed 1.0 mm and provided, that when the warp is greater than 1.6 mm an extra anchor hole shall be drilled near the proper corner and the piece drawn into position thereby. All bolt heads on the exposed face shall be countersunk and fitted or ground so that the heads are flush with the finished surface. Joints between abutting sections shall be square and flush and the butting ends shall be sawed or otherwise made smooth and regular.

(h) Metallic Coatings

(i) Zinc Coatings

Zinc coatings shall be applied in a manner and of a thickness and quality conforming to 1.1.11.12 "Galvanising".

(i) Castings and Forgings

(i) General

Each casting shall have the mark number cast upon it. Each forging shall have the mark number stamped upon it. Dimensions of casting shown on the approved shop drawings will be the finish dimensions.

(ii) Castings

Repairs to castings shall not be made without the knowledge and prior approval of the Engineer. Deviations from the dimensions and the thickness of castings, will not be permitted to exceed such amounts as will impair, by more than 10 percent, the strength of the castings as computed from the dimensions shown. Warped or otherwise distorted castings or castings that are oversize to such an extent as will interfere with proper fit with other parts of the machinery will be rejected. The structure of the metal in the castings shall be homogeneous and free from excessive non-metallic inclusions. Excessive segregation of impurities or alloys at critical points on a casting will be a cause for rejection.

(j) Patterns

In the construction of patterns, care shall be taken to avoid sharp corners or abrupt changes in cross section, and ample fillets shall be used. The Contractor shall add such draft and increases in pattern thicknesses as will conform to this standard

foundry practice and as may be necessary to ensure that all metal thickness of the finished castings will be in accordance with the dimensions and tolerances specified.

(k) List of Materials

When so requested by the Engineer, the Contractor shall furnish three (3) copies of all purchase orders, mill orders, shop orders for materials, and work orders, including all orders placed by each manufacturer. Where mill tests are required, the purchase orders shall contain the test site address and the name of the testing agency. The Contractor shall also furnish a shipping bill or memorandum of each shipment of finished pieces or members to the project site, giving the designation mark and weight of each piece, the number of pieces, the total weight, shipping line and number. Copies of certified shipping bills, in duplicate, shall be delivered promptly.

(l) Shop Assembly

Machinery and structural units furnished shall be assembled in the shop. Items to be shop assembled shall be as specified. An inspection shall be made to determine the correctness of the fabrication and matching of the component parts. The tolerances shall not exceed those specified and each unit assembled shall be closely checked to ensure that all necessary clearances have been provided and that binding does not occur in any moving part. Assembly and disassembly work shall be performed in the presence of Engineer's representative, unless exempted in writing by the Engineer, and any errors or defects disclosed shall be immediately remedied by the Contractor. Before disassembly for shipment each piece of a machine or structure shall be match-marked to facilitate erection in the field. The location of match-marks shall be indicated by circling with a ring of white paint after the shop coat of paint has been applied, or as otherwise directed.

(m) Field Assembly

(i) General

All parts to be installed shall be thoroughly cleaned; all packing compounds, rust, dirt, grit and other foreign matter removed; all holes and grooves for lubrication cleaned; and all enclosed chambers or passages examined to make sure that they are free from injurious materials. Where units or items are shipped as assemblies they will be inspected by a representative of the Engineer, prior to installation. Disassembly, cleaning and lubrication will not be required except where there is indication that such work is necessary to place the assembly in a clean and properly lubricated condition. The top of all steel floor plating and gratings, shall be installed flush with abutting curb surfaces. Stillon wrenches, cold chisels, or other tools, likely to cause injury to the surfaces or rods, nuts, or other parts, shall not be used for the work of assembling and tightening parts. Bolts and screws shall be tightened firmly and uniformly, but care shall be taken not to overstress the threads by using excessive force or wrenches of excessive length. When a half nut is used for the purpose of locking a full nut, the half nut shall be placed first and followed by the full nut. Threads of all bolts, nuts, and screws shall be lubricated by lead and oil before assembly. Driving and drifting bolts or keys will not be permitted.

(ii) Alignment and Setting

Each machinery or structural unit shall be accurately aligned by the use of steel shims, or other approved methods, so that no binding in any moving parts or distortion of any members occurs before it is finally fastened in place. The alignment of all parts with respect to each other shall be true within the respective tolerances required. The machines shall be set true to the elevations.

(iii) Blocking and Wedges

All blocking and wedges used for the support during installation, of parts to be grouted in, shall be removed before final grouting, unless otherwise directed by the Engineer. Blocking and wedges, left in the foundation with the approval of the Engineer, shall be of steel or iron.

(iv) Foundations and Grouting

Concreting of sub-bases and frames and the final grouting under parts of machines shall be in accordance with the procedures as specified in Section 1.1.2.

(n) Tests and Trials

(i) General

The Contractor shall at his expense, perform analyses and tests to demonstrate that all materials are in conformity with the specifications, except where such tests are waived in writing by the Engineer. Should the Contractor desire to use stock materials, not manufactured specifically for the work covered by these specifications, he shall submit evidence, satisfactory to the Engineer, that such material conforms to the requirements of the specifications and detail tests of these materials will not be required, if so approved by the Engineer. Tests, except where modified, shall be made as indicated in the respective specifications and, unless otherwise authorised, in the presence of the Engineer. The Contractor shall furnish certified reports in triplicate of all required analyses and tests. The Contractor shall furnish, upon request, specimens and samples for independent analysis and test, all properly labelled and prepared for shipment.

(ii) Analysis of Material

The Contractor shall furnish certificates listing the serial numbers and the chemical and physical properties of metals tested. The Engineer shall notify the Contractor in writing the items requiring data.

(iii) Non-Destructive Testing

When doubt exists as to the soundness of any part, such part may be subjected to any form of non-destructive testing as determined by the Engineer. This may include ultrasonic, magnetic, dye penetrant, X-ray, gamma-ray or any other test that will thoroughly investigate the part in question. The cost of such investigation shall be borne by the Contractor with no additional cost to the Employer. Any defects in composition or grain structure will be a cause for rejection and the rejected part shall be replaced and re-tested at the Contractor's expense.

(iv) Tests of Machinery and Structural Units

Each complete machinery and structural unit as required by the Specification shall be erected and tested as specified in SECTION 1.18 "TESTING OF MECHANICAL PLANT", unless exempted by the Engineer. Waiving of tests, however, shall not relieve the Contractor of responsibility for any fault in operation, workmanship, or material that may later develop before the completion of the Contract or the Maintenance Period. After being assembled in place at the site, each complete machine or structural unit shall be tested to demonstrate that it meets specification requirements in all respects and is suitable for performing the work intended. The details for tests on the various machinery and structural units shall conform to the requirements of the pertinent Sections of this Specification.

Tables of Minimum Camber

Span of Joints (meters)	Minimum Camber at Centre (centimetres)
12 ≤ < 15	1.0
15 ≤ < 18	2.0
18 ≤ < 21	3.0
21≤ < 24	4.0
24 ≤ < 27	5.0
27 ≤ < 30	6.0
30 ≤ < 36	7.0

1.11.11 Aluminium Work

(a) Scope of Work

Provide all labour, materials, equipment and incidentals required to furnish and install aluminium windows, louvers, and screenings including frames and accessories.

(b) Shop Drawings and Approvals

Contractor shall submit for approval shop drawings showing details of construction, descriptive literature and samples of each type proposed, along with the name and details of the manufacturer or fabricator.

(c) Materials and Components

(i) Windows Louvers and Frames

The material shall be conforming to ASTM B 221, alloy 6063, Temper T5 and shall be anodised to a thickness of 20 microns in bronze colour. The components shall be fabricated of extruded aluminium sections and plates. The thickness of the sections shall be 1.2 mm minimum.

(ii) Screenings

Insect screens shall be of aluminium gun metal 18 x 16 mesh, 2.8 mm gauge aluminium wire.

(iii) Accessories

Fastening devices such as screws, bolts, nuts, rivets etc., shall be of aluminium or stainless steel. Washers shall be of neoprene rubber, aluminium or stainless steel.

Sealing materials shall be of poly-sulphide rubber.

(d) Installation

All external faces of aluminium shall be applied with peelable protection film or the like before despatching from the factory. The insect screen shall be mounted on a removable frame to the inner side of the window frame. The windows shall have locking devices, hinges etc., to the approval of the Engineer.

Where aluminium faces come into contact with steel, masonry or other materials, they shall be treated with a coat of Zinc Chromate or alkali - resistant bituminous paint before installation.

1.11.12 Galvanizing

(a) Scope of Work

The Contractor shall furnish all labour, materials, equipment and incidentals necessary to galvanise all materials specified. Materials shall be galvanised by the hot dip or electro depositing process, unless noted otherwise.

(b) Workmanship

The zinc coating shall adhere tenaciously to the surface of the base metal. The finished product shall be free from blisters and excess zinc, and the coating shall be even, smooth, and uniform throughout. Machine work, die work, cutting, punching, bending, welding, drilling, thread cutting, straightening and other fabricating shall be done as far as is practicable before the galvanising. All members, nuts, bolts, washers and appurtenances shall be galvanised before a structural unit is assembled. All un-coated spots or damaged coatings may be cause for rejection. Repair of damaged coatings will be at the discretion of the Engineer.

Products that are warped or distorted to the extent of impairment for the use intended, shall be rejected.

It will be the responsibility of the Contractor to:

1) Adequately design all items for galvanising
2) Properly select all steel for its suitability to be fabricated and to withstand normal galvanising operation.
3) Prevent damage to the material by over pickling or by use of excessively high temperatures.

All material shall be provided without embrittlement. Workmanship shall conform to ASTM A143, "Practice for Safeguarding against Embrittlement of Hot Galvanised Structural Steel Products and Procedure for Detecting Embrittlement.

(c) Test Coupons

Test coupons, for determining the quantity and quality of the galvanising, shall be of such size and shall be wired to the materials to be galvanised before immersion so as to represent the amount of coating deposited on the finished product.

Non-destructive tests for uniformity of coating may be ordered to be made with a magnetic instrument in accordance with ASTM E376, "Measuring Coating Thickness by Magnetic Field or Eddy Current (Electromagnetic) Test Methods". If tests are ordered by the Engineer, they shall be paid by the Contractor with no additional cost to the Employer.

(d) Cleaning

After the shop work has been completed and accepted all material shall be cleaned of rust, loose scale, dirt, oil, grease, and other foreign substances and pickled. Particular care shall be taken to clean slag and spatter from welded areas. Pickling shall be completed in such a manner to ensure the total removal of all acid, prior to galvanising.

(e) Galvanising

(i) Plates and Shapes

All plates and shapes shall be galvanised after fabrication. After being cleaned, all materials shall be zinc coated (galvanised) in accordance with ASTM A-123, "Zinc (Hot-Galvanised) Coating on Products Fabricated from Rolled, Pressed and Forged Steel Shapes, Plates, Bars and Strip" or BS 729 - " Hot dip galvanised coatings on Iron and Steel articles". Where members are of such lengths that they cannot be dipped in one operation, great care shall be exercised to prevent warping. Finished compression members shall not have lateral variations greater than 1/1000 of the axial length between the points which are to be supported laterally. Finished tension members shall not have lateral variations exceeding 3 mm for each 1.5 meters of length. Sharp kinks of bends will be a cause for rejection of the material. All holes in material shall be free of excess swelter after galvanising.

No machine or shop work, die work, punching, or grinding, will be allowed after galvanising.

(ii) Hardware

Bolts, nuts, washers, lock-nuts, and similar hardware shall be galvanised in accordance with ASTM A-153, "Zinc Coating (Hot Dip) on Iron and Steel Hardware" Excess swelter shall be removed by centrifugal spinning. The Contractor shall submit samples of bolts and nuts for approval. Nuts and tapped holes scheduled for galvanising shall be oversized tapped or re-tapped prior to galvanising. Tapping or re-tapping of threads after galvanising will not be permitted.

(iii) Assembled Products

Galvanising of shop fabricated items shall be the hot-dip zinc process, after fabrication. All assembled products shall be assembled and prepared in accordance with ASTM A385, "Practice for Providing High Quality Zinc Coatings (Hot Dip) on Assembled Products".

Following all manufacturing operations, all items to be galvanised shall be thoroughly cleaned, pickled, fluxed and completely immersed in a bath of molten zinc. The resulting coating shall be in accordance with ASTM A386, "Zinc-Coating (Hot Dip) on Assembled Steel Products". The coating shall have an average weight of 550 grams per sq. m unless noted otherwise. The testing of zinc coat shall be in accordance with ASTM A386 or any international standard.

(iv) Pipe

Galvanising of pipe shall be in accordance with Section 2.7 of BS1387, "Steel Tubes and Tabulars Suitable for Screwing to BS21 Pipe Threads"

(e) Straightening

To minimise straightening, all work shall conform to ASTM A384, "Practice for Safeguarding Against Warpage and Distortion During Hot-Dip Galvanising of Steel Assemblies".

All plates and shapes which have been warped by the galvanising process shall be straightened by being re-rolled or pressed. The material shall not be hammered or otherwise straightened in a manner that will injure the protective coating. If, in the opinion of the Engineer, the material has been harmfully bent or warped in the process of fabrication or galvanising, such defects shall be cause for rejection.

1.12 Ventilation

1.12.1 General

The ventilation system shall be designed for five changes per hour of the total volume of air inside the Pump Station building or the required rate of flow to keep the temperature inside the building at ambient condition, which ever is greater. In calculating the heat load inside the building the total heat generated by motors, electrical panel boards and cables shall be taken into account.

Where centrifugal fans are offered they shall be supplied with backward curved blades for their non-overloading power curve and stable operating characteristic. Where axial flow fans are employed spring or gravity return flaps shall be employed in the ductwork system in order to prevent overload.

The volume flow and system resistance at the duty point shall be determined for all applications. The mounting of fans with the ductwork system or air handling unit shall be such that vibration isolation is achieved.

The ventilation ductwork shall be fabricated in galvanised mild steel.

All seams, joints and connections to plant shall be made so as to reduce air leakage to a minimum. All internal roughness and obstructions shall be restricted to those intended such as duct turning vanes at square elbows and control dampers.

Ductwork shall be firmly held in position and be free from vibration and drumming of panels at the operating frequencies.

Both expansions and Contractions shall have a maximum slope of 30 degrees on any side. Where flexible ducting is used it should be as short as possible and should not exceed 200mm. All finished ductwork should be free of sharp edges and other hazards which may cause injury to personnel.

1.12.2 Materials and Material Finish

Metal ductwork shall be manufactured from strip mill cold reduced sheet steel, continuously hot dip galvanised to BS 2989 Group 2 Class 2A or equivalent. The material thickness used and stiffening, if required, shall be determined by the larger duct dimension at any transition.

1.12.3 Joints

The sealants used at joints shall be of the liquid mastic type which permanently retains adhesion and elasticity throughout a temperature range of 8°C to 70°C. The sealant should be applied with a brush or gun and shall completely seal the joint. The ductwork must not be pressurized until the sealant is cured. Duct tapes shall not be permitted at any joint.

Gaskets shall be of an elastic material suitable to this particular case.

Galvanised bolts and fittings are to be used on all flanged connections, brackets and ductwork fittings together with lock nuts or approved lock washers.

Horizontal rectangular ductwork shall be supported mainly from cantilever brackets fabricated from rolled steel angle projecting 50mm on each side of the duct. All steelwork supports shall be galvanised.

The supports shall be spaced at not more than 1.8m centres according to size and rigidity of the duct. Supports are to be provided at all branches, off takes, bends etc. and at all main flanged joints and shall be complete with approved anti-vibration mounting.

All hangers shall have secured sections incorporated for adjusting of ductwork alignment.

1.12.4 Control Dampers

A regulating damper shall be installed in the supply and intake ductwork. Dampers on ductwork 150mm high or less shall be single blade dampers constructed from galvanised steel. The blade shall be rigidly fixed to a mild steel spindle, the ends of which shall be housed in nylon or PTFE bearings.

Dampers on ductwork greater than 150mm high shall be of the opposed blade multi-leaf type, each leaf consisting of two plates of material of the same thickness as the corresponding ductwork. These shall be rigidly fixed to each side of a mild steel operating spindle, the ends of which shall be housed in a nylon or PTFE bearing.

The ends of the spindles shall be linked so that one movement of the operating handle shall move each leaf an equal amount.

Individual damper blades on multi-blade units shall not exceed 1500mm in height.

All dampers shall be fitted with lockable quadrant handles and each shall be complete with a pair of flanges to form a damper unit.

1.12.5 Louvers

Fresh air intake and exhaust air louvers shall have fixed blades angled to provide adequate weather protection and shall normally have a minimum free area of 60% measured at 90 degrees to the air flow. Louvers shall be made from steel with blades not less than 3mm thick, having vertical supports necessary to ensure complete rigidity. All louvers shall be fitted with a bird screen.

The Tenderer shall indicate in the relevant technical schedule the sound pressure levels for each fan across the frequency range, attenuation and the resulting sound pressure level at 1 metre from the inlet or discharge louver

Grilles shall be supplied and installed as required and manufactured from aluminium or mild steel.

Removal access covers shall not be larger than 375mm by 300mm high. The opening of the duct shall be adequately reinforced and the cover sufficiently rigid to prevent distortion. A suitable sealing gasket shall be provided with sufficient fastenings to ensure an air tight seal.

Where ductwork, fans and duct louvers connect to builders' work, connections shall be built into timber frames supplied by the Contractor.

In all cases the duct end must be finished with a mating flange and where this is fixed to a timber frame the flange should be wide enough to overlap the joint between timber and masonry by at least 25mm.

Joints between mating flanges and companion rings or hardwood frames shall be fitted with a sealing gasket. Penetrations through walls and floors must be carefully detailed and angle frames provided, if necessary, to act as a retaining for packing, to prevent noise and vibration or to accommodate movement due to expansion.

Where ducts penetrate external walls and floors a flange suitable for flashing must be fixed and sealed to the duct and wall.

1.13 Fire Protection and Safety Equipment

1.13.1 Portable Fire Fighting Equipment

Portable fire extinguishers shall be provided in all control rooms, laboratories, offices, workshops and any other area where fire might break out.

Extinguishers shall be of the Water Type or Dry Powder Type or CO2 type depending on the location and possible hazard.

In general, water type extinguishers shall be used for Class A risk areas and shall be 9 litre capacity.

Extinguishers shall be suitable for electrical, chemical and oil fires and shall contain not less than 5 kg of extinguisher. Extinguishers shall be colour coded and clearly marked with their type and the class of fire for which they are suitable and comply with the relevant ISO or DIN standards.

The numbers and dispositions of extinguishers shall be in accordance with any local requirements and shall be agreed with the Engineer.

1.13.2 Compressed Air Breathing Sets

Compressed air breathing sets shall be provided wherever dangerous chemicals are stored.

The sets shall comprise harness, back plate, air bottle, pressure reducer assembly, demand valve, contents gauge, facemask and all necessary air hose and fittings. Air bottles shall be sized to give an endurance of not less than 30 minutes.

The sets shall be located in steel or GRP enclosures having a clear glass or PVC front so that any deficiency in the equipment shall be apparent.

The location of the cabinets shall be agreed with the Engineer.

1.14 Lifting Equipment

1.14.1 General

All runway beams and associated lifting gear shall be designed to facilitate installation and maintenance of pump units, and their associated pipework, valves etc.

1.14.2 Construction - Runway Beams

(a) Runway Beam

- Runway beams and supporting structures shall be designed, erected and tested in accordance with BS 2853 or equivalent and BS 449 or equivalent.
- The materials utilized in the plant shall be the most suitable for the duty concerned and shall be new and of first class commercial quality. Steelwork shall be in accordance with BS 4360 or equivalent.
- The support framework shall be of bolted construction and all bolting shall be in accordance with BS 4395 or equivalent and BS 4604 or equivalent.
- Hand operated hoists shall be of robust steel construction, grade 80 load chain, complete with a safety hook to BS 2903 or equivalent and load limiter.
- The traveling trolley shall be of robust design and incorporate safety lugs to prevent the fall of the trolley in the event of an accident. The safety lugs shall also incorporate buffers to prevent damage in the event of collision with the runway beam stops.
- The runway beam shall be fitted with stop ends which shall be clamped to the beam in order to prevent over travel of the traveling trolley.

- Runway beams used externally shall be provided with an accommodation cubicle to protect chain block or traveling trolleys from the weather.
- Runway beams shall be painted in accordance with this specification. The final paint colour for internal plant shall be yellow code 08 ESI, and for external plant dark green, code 4C 39 to BS 4800 or equivalent.

(b) Main Long Travel Drives

- Twin wheel drive systems are to be provided with fully enclosed gears. Gearbox Units are to be shaft mounted and keyed onto tram wheel axle extensions either side of the crane bridge.

(c) Hoist Assemblies

- Crab frame assemblies for double girder cranes are to be supported on four double flanged runners keyed to axles rotating in roller ball journals. The hoist unit is to be fixed into the main frame to enable the whole assembly to travel along the rails. Rails are to be welded to the top flange of each bridge girder or securely bolted.
- Single girder cranes require the hoist unit to be suspended from a trolley installation requiring roller ball bearings and single flange runners enabling travel on the bridge of the girder lower flange.
- Chain hoists shall be provided with chain boxes.
- All hoists are to be provided with chain guides and pressure rings as standard fittings to ensure correct chain receiving during operation.

(d) Hook Block

- Hooks shall be forged steel to BS 2903 or equivalent, tested to 150% full load before assembly and complete with safety catch. Hooks shall be supported by a heavy duty thrust bearing fitted to the main trunnion and provide 360o rotation of the hook.
- Mild steel rope sheaves shall be fitted with anti friction bearings and are to be fully guarded with steel casings.

(e) Lifting Chains

- Material

  Lifting chains shall fully comply with BS 4942 Parts 1 and 2 or equivalent with a minimum UTS of 540MN/m2

- Chain Type

  Chains shall be of the short link type.

- Master links

  Master links shall be provided with clearance of 75mm and shall be fitted at each end of the lifting chain and at 1700mm centres.

– Shackles

Both ends of the chain shall have a permanently attached shackle, having a jaw width of 25mm minimum complete with type A collared pins to BS 3032 or equivalent.

– Identification

The top and bottom master links to be hard stamped with the SWL.

– Safe Working Load

SWL is to be a minimum of 1 tonne but shall be suitable for the required application.

– Length

The chain shall be a minimum of 1700mm long but of suitable length to enable removal of the pump plant by standard equipment.

1.14.3 Gantry Overhead Traveling Cranes

(a) General

Overhead cranes shall be designed erected and tested in accordance with BS 466 or equivalent, BS 2573 Part I Structures and Part 2 - Mechanisms or equivalent. Materials utilised shall be the most suitable for the concerned duty, shall be new and of first class commercial quality. Steelwork shall be in accordance with BS 4360 and BS 4 or equivalent.

(b) Bridge Assembly

The bridge unit shall be designed to BS 2573 or equivalent and of rigid construction able to withstand horizontal and vertically imposed stresses during operation permitted within BS 466 or equivalent deflection ratios.

Dimensional accuracy and alignment requires jig assembly of components.

(c) Girders

Bridge girders shall be constructed to BS 4360 or equivalent and BS 4 or equivalent structural steel with substantial plated stiffener at each end to provide a rigid connection with broad gusset plates for end carriages. Girders are to be provided with safety long travel end stops to prevent over travel of the hoist carriage. Long travel stops are to engage the hoist wheel treads.

(d) End Carriages

End carriages are to be fabricated from rolled steel to produce a stiffened box section to provide high tensional resistance. Wheel box housings are to be jig assembled at the end of each end carriage to produce accurate bolt alignment in accordance with BS 4395 and BS 4604 or equivalent. Rubber buffers are to be fitted to each end of both end carriages.

(e) Tramwheels

Tramwheels arc to be provided with double flanges and supported by a substantial live axle. Axles are to be mounted with spherical roller bearings located either side of the wheel supported by the wheel box housing. Design of end carriage wheel assembly must enable easy access and removal of road wheels.

1.14.4 Electrically Operated Cranes

(a) Main Long Travel Drives

Design shall include for low starting torques as provided by normally ventilated squirrel cage motors to enable smoothly driven motions transmitted by helical reduction gear boxes fitted with resilient torque arm mountings.

All drive units are to incorporate automatic adjustable electro-magnetic brakes to enable gradual deceleration and prevent excessive over-travelling.

(b) Cross Travel Motion

Cross travel motion is to be provided driven through a pair of runner wheels. Drive design shall include for an accelerating torque characteristic suitable for crane duties, normally provided by squirrel cage motors required to be flange mounted on to the gearbox to enable smoothly driven motions transmitted via reduction spur gearing.

Drive units to incorporate automatically adjustable electro-magnetic brakes.

(c) Hoist Drum

Hoist drums are to be manufactured from heavy duty, seamless, steel tube supported on high quality anti-friction journals installed in the main frame side plates.

(d) Hoist Gearbox

Hoist gearboxes shall comprise oil immersed, triple reduction gear train, self contained in a cast housing. Gears are required to be heat treated to provide maximum wear resistance. High speed gears are to be manufactured with helical teeth configuration. Geared shaft assemblies are required to be supported on ball or roller bearings.

(e) Hoist Brakes

Hoist brake design shall incorporate a single disc, fail safe type. It is to be spring applied with magnetic coil release and to be suitable for arduous heavy duty hoists. Coils are to be direct current energised with rectifiers, to ensure positive action. Brake units are to be directly fixed to the main gear case and operate on the primary drive shaft to provide a fail safe operation on the driven side of the flexible coupling.

Brake units are to be located in a readily accessible location for periodic safety checks and maintenance inspections.

The design is to incorporate independent switching of the motor back surge for additional safety with fail-safe operation to sustain loads in event of an interrupted power supply. Hoist design to incorporate mechanical hand release to enable lowering of hook block in event of power failure.

(f) Hoist Motors

mounted to the main hoist frame side plates and connected to the gearbox via a flexible coupling. Hoist motor design shall incorporate duty parallel rotor fan cooled squirrel cage machines rated at 40% EDM and 240 starts/hour. Insulation is to be Class F to IEC Standards and protection shall be to ISO IP54.

Hoist motors are to be flange Dual speed operation of the motor is required for creep speeds operated from double depression control buttons.

(g) Limit Switch

Auto-reset safety limit switches are to be provided to prevent over hoisting or lowering of the hook block.

Switches are to be positive action operated by movement of the hoist rope hand.

(h) Electrical Assembly

“Hold on” push buttons are to be provided for all motions, each motion to be electrically interlocked and operating in conjunction with mechanically interlocked reversing contactors. Low voltage control is required at the push button controller.

Control pendants are to conform to IEC 144 Class IP65 manufactured from oil-tight low density polythene, resistant to corrosion and shock. Pendant units are to be suspended from the trolleys located in a steel track fitted across the full span of the crane providing a mobile control feature. Pendants to be provided with indication arrows and hung with a steel cable with plug and socket connection.

(i) Control Gear

Electrical contactors are to conform to BS 775 or equivalent, category AC4, Mechanical Class IV, duty rating of 240 operations per hour. Triple pole reversing contactors are to be mechanically interlocked for operator protection to minimise the potential for short circuit due to vibration. Hoist and traverse contactors are to be housed in sheet steel compartments with control circuits protected by HRC fuses on each phase

Main control panel to contain low voltage transformers, with main travel mechanically interlocked contactors for isolation of control via the stop/reset buttons. H RC fuses are required for full motor circuit protection.

(j) Cross Conductors

Electrical feed to the hoist unit is to be provided through looped platform. Flexible cables suspended from trolleys and supported by a steel track across the crane span. Cables to be ISO Grade PVC, sheathed, PVC insulated.

(k) Motors

Motors shall be rated for crane usage, solid rotor machines with parallel stator windings and Class F insulation. Electro-mechanical brakes are to be provided for each motion.

(l) Operating Temperatures

Motors, control gear and cabling shall be rated for a required duty at a maximum ambient temperature or alternatively 50°C, which ever is greater.

1.14.5 Manually Operated Gantry Crane

(a) Main Long Travel Motion

Long traverse motion shall be achieved either by 'hand push' or by chain operated gears shall mounted and keyed onto the tram wheel axle, in accordance with BS 2573:Part2 or equivalent.

(b) Cross Travel

The travelling trolley shall be of robust design incorporating buffers to prevent damage in the event of collision with the stops.

Cross travel motion shall be achieved by either 'free wheel or by chain operated gears keyed onto the trolley wheel axle, all in accordance with BS 2573 Part 2 or equivalent.

(c) Lifting Mechanism

The lifting mechanism shall be hand operated chain and block and shall comply with BS 3243 or equivalent "Specification for Hand Operated Chain Blocks".

(d) Gears & Bearings

Anti friction bearings shall be installed in accordance with manufacturer's instructions with facility for greasing.

Gear calculations shall be in accordance with BS 436 or equivalent, 545 or equivalent & 721 or equivalent.

(e) Gantry Lifting Frame

(i) Design and Fabrication

The gantry lifting frame shall be designed and fabricated from mild steel in full compliance with the relevant British Standards. The Fabrication shall be fully welded and grit blast prior to galvanising to BS 729 or equivalent and BS 5493 or equivalent.

(ii) Safe Working Load

The safe working load of the gantry frame shall be a minimum of 500kg, but shall be suitable for the required application, and at the design stage all calculations and drawings shall be submitted for approval.

(iii) Lifting Frame and Hoist Trolley

The frame shall be designed on the basis that only one pump will be lifted at any one time.

A hoist trolley shall be fitted to the runway beam, and the runway beam shall coincide with the centreline of the pumps.

(iv) Testing

The Contractor shall be fully responsible for testing the lifting gantry frame at site and for the provision of the necessary certificate for insurance purposes. The test weights required for testing shall be supplied by the Contractor.

1.14.6 Lifting Davits

(a) Design and Fabrication

The two piece lifting davit shall be designed and fabricated from mild steel in full compliance with the relevant British Standards. The fabrication shall be fully welded and galvanised to BS 729 and BS 5493 or equivalents.

(b) Safe Working Load

The safe working load of the davit shall be a minimum of 250kg. But shall be suitable for the required application, and the Contractors shall submit drawings and calculations for approval.

(c) Testing

The Contractor shall be fully responsible for testing the two piece davit and all shackles (where more than one is supplied) at site and for the provision of the necessary certificates for insurance purposes. The test weights required for testing shall be supplied by the Contractor.

1.14.7 Painting

(a) General

Painting shall be carried out in full accordance with the paint manufacturer's instructions. The final colour of the paint for internal plant shall be Yellow, code 08 E 51 and the paint finish for external plant shall be Dark Green, code 14 C 39 to BS 4800 or equivalent.

(b) Paint - Trolley and Hoist

The standard manufacturers paint finish shall be thoroughly scuffed to provide a mechanical key and painted to the requirements of the specification.

1.14.8 Testing

The Contractor shall be responsible for testing lifting equipment on site. Tests shall cover all certification for insurance purposes and include proof load testing of the plant. The Contractor shall be responsible for the supply of all certified weights necessary for the testing of the lifting equipment supplied under this contract. A

proof load of 2 times SWL shall be applied after installation to all equipment supplied under this contract.

The result of all proof load tests carried out by the Contractor shall be recorded, certified and submitted to the Employer in triplicate.

1.14.9 Marking

The safe working load and identification number shall be plainly and permanently marked on the runway beam so as to be clearly visible to the operator. In addition the beam shall be stamped with both the safe working load and the identification number.

A brass data plate shall be fixed to the indoor runway beam stop and shall be stamped with the following information.

(a) the manufacturer's name and address
(b) the Proof Test Load
(c) the Safety Working Load
(d) the date of the initial test
(e) blank space (for NWS&DB identity number).

1.15 Air Vessels and Associated Equipment

1.15.1 General

Air vessels for surge protection shall be provided as detailed in the Particular Specification to control pressure transients in pump suction and delivery mains and to protect the supply system from negative pressures. Air vessels shall be designed in accordance with BS 5500 or equivalent "Unfired Fusion Welded Pressure Vessels".

1.15.2 Design

Each vessel shall be required to work between 0°C and +40°C

Each vessel shall handle water and compressed air with a water line approximately 75% from the bottom of the vessel. The vessel shall be suitable for use with water of the quality specified or described in the Particular Specification for the location concerned.

Longitudinal seam welds shall not cross at any intersection with circumferential welds but shall be offset a minimum length corresponding to 90° of shell circumference.

In allowing for corrosion it should be assumed that the vessel life is expected to be 25 years. The corrosion allowance shall be not less than 2.0mm.

1.15.3 Vessel Geometry

Surge vessels shall be fabricated from carbon manganese steel, full details of which shall be supplied by the Contractor before fabrication. The vessel shall comprise

two domed ends with an intermediate cylindrical section. Vertical mounting is preferred. Not less than two lifting lugs shall be provided for lifting the complete vessel.

The inlet and outlet pipework shall be designed to the same criteria as the vessel, terminating in flanged connections to BS 4504 NP 16 or equivalent rating in association with the pumping plant pipework. A drain line shall be provided complete with isolating globe valve and flanged hose connection suitable for a flexible 50mm hose.

The vessel shall be supplied complete with sight glass and associated fittings, internal inspection port, manhole access, level control switches, pressure gauges and safety pressure relief valves.

Support legs shall be thick section equal angle steel incorporating drilled feet for levelling and bolting down of the vessel.

1.15.4 Sight Glasses

The Contractor shall supply two flanged entries for sight glasses on the vessel. The liquid level should be uninterrupted over the length. The maximum operating pressure of the sight glass shall be higher than the design pressure of the vessel. In the event of glass failure the vessel shall remain pressurized.

The sight glass shall be provided with flanged isolating valves complete with ball check and displacement device plus drain cock. The sight tube shall be protected with a stainless steel guard and all round polycarbonate protector. When necessary the sight glass shall be supported at the centre from the surge vessel side wall.

1.15.5 Inspection Port

An elliptical inspection port approximately 320 x 220mm of the type that incorporates an internal “pull up” plate with self scaling joint tightened by exterior draw bolts on a port bar shall be provided in the cylindrical section of the surge vessel below top water level, the details of which must be shown clearly on a general arrangement drawing.

1.15.6 Man access Flange

A man access hole of not less than 500mm internal diameter shall be provided in the cylindrical section of the vessel to permit access from ground level. This shall be covered with a suitable flange which shall be bolted onto a fabricated flange on the man hole.

The man access flange cover shall be provided with a lifting swing davit which shall incorporate a lifting screw, so that the whole flange cover may be lifted up and then swung out from the entry port. The davit may be fabricated onto the cylindrical wall of the vessel.

Service points shall be provided. Four of these points shall be drilled and tapped entries for level control switches. A further drilled and tapped entry shall be

required for the supply air and pressure gauge line and one other entry point shall be provided with a flanged entry for the safety relief valves. All entry points into the main access flange shall be bossed out to suit the size of the tapping or hole.

1.15.7 Safety Relief Valves and Pressure Gauge

A three way plug valve, with no neutral shall be mounted on the main access flange, with two in number safety relief valves mounted either side of the plug valve outlets. The safety valves shall be suitable for air/water and rated for the pressures likely to be experienced. They shall be adjustable and incorporate a manual lift device or wedge for testing purposes.

A pressure gauge shall be mounted not less than 1m above floor level, have a 100mm diameter face and be complete with isolating valve and a drip leg drain. The pressure gauges shall be of the liquid filled type. The location and orientation of the pressure gauge shall be subjected to the approval of the Employer's Representative.

1.15.8 Bolting and Gaskets

All nuts and bolts for all flanges and fittings shall be stainless steel.

Gaskets shall be rubber insertion or other suitable elastomer material approved for use with potable water conforming to BS 2494 or equivalent. Spiral wound gaskets are not permitted.

1.15.9 Inspecting Authority

The Contractor shall employ directly an approved Inspecting Authority for these works in compliance with BS 5500 or equivalent.

The Contractor shall make provision for all the necessary work associated with carrying out the Inspecting Authority's recommendations resulting through the use of BS 5500 or equivalent in assessing design, manufacturing procedure, documentation and testing of the vessel etc.

1.15.10 Radiographic Testing

The contractor shall allow for 100% category 1 radiographic testing

1.15.11 Welding

Welding shall only be carried out by Contractor's staff that are qualified and experienced to undertake this work in accordance with BS 5500 or equivalent by reference to the following:

(a) BS 4870 Approval Testing of Welding Procedures or equivalent
(b) BS 4871 Approval of Welders working to Approval Welding Procedures or equivalent

1.15.12 Marking of Vessels

The Contractor shall mark vessels clearly with their respective safe working pressure in lettering not less than 80mm in height in gloss paint.

A brass plate shall also be fixed to each vessel which will state:

(a) name of manufacturer with address
(b) Identification number
(c) Employer's contract number
(d) shell thickness
(e) corrosion allowance
(f) shell diameter
(g) head diameter
(h) head thickness
(i) head corrosion allowance
(j) degree of X ray inspection
(k) design pressure
(l) hydraulic test pressure
(m) weight
(n) length
(o) inspection date
(p) inspector's initials
(q) safe working pressure

1.15.13 Compressors

One duty and one standby electrically - powered compressor shall be provided with each air vessel.

The Contractor shall supply the compressors together with self contained control panels. These will be supplied with power from new switchboards from suitably rated circuit breakers and fitted with a suitably rated overload trip.

The compressors shall be the oil-less piston type and be mounted adjacent to the air vessel. Each compressor shall be capable of producing a volume of air at the working pressure in conjunction with the air vessel, be controlled by two of the level probes mounted within the vessel, and have a capacity of not less than 1 litre/second free air delivery.

The compressors shall be of rugged design to provide a reliable and efficient operation with a minimum of maintenance. In particular the suction and discharge valves and pressure regulating system shall be designed to guarantee a long and trouble free life. Each compressor shall be provided with an air filtering, down-loading valve. The non- return valve shall be fitted with resilient seats and be fitted directly to the surge vessel.

Interconnecting pipework shall be galvanised steel or other approved material complying with the contract pipework specification.

The following components are to be provided and assembled in a single unit ready for start-up:

- Compressor;
- Squirrel cage three-phase motor 230/400 V ±10%, Pf 0.85, 50 Hz;
- Base plate with vibration dampers;
- Flexible coupling or V-belt with guard;
- Anchor bolts with nuts and washers of galvanised steel;
- Pressure gauge, diameter 60 mm, with valve and connecting fittings R ½";
- Air inlet filter;
- Isolation valve;
- Safety valve, spring loaded;
- Non-return valve;
- Joints and connecting material (screws, nuts, washers, etc.) of galvanized steel;
- Accessories for start-up (grease, oil, etc.); and
- Protection and final coating.
- The motor must be able to start against the working pressure
- The equipment shall be designed for an internal pressure 1.5 times higher than the working pressure

1.15.14 Air Blower

(a) General

Blower units shall consist of packaged type blowers electric motors and all necessary appurtenances to provide complete blowing system. The contractor shall require that all the blower units specified herein be supplied by a single manufacturer.

Packaged type blower shall be of the positive displacement type designed to provide necessary quantity of oil free air at the required pressure to carry out back washing operations of filters in water supply schemes.

The contractor shall cause all equipment specified under this contract to be furnished by the blower manufacturer who shall be responsible for the adequacy and compatibility of all blower unit components. Any component of each blower unit not provided by the blower manufacturer shall be designed, fabricated tested and installed by factory authorized representatives experienced in design and manufacturer of such components. This requirement, however, shall not be construed as relieving the contractor of the overall responsibility for this portion of work.

Blower units shall be designed to operate without harmful noise or damaging vibration at the specified speed, flow and pressure conditions.

The base shall be designed for anchor bolting to a concrete foundation.

The motor shall be supported independently on the base and it shall be connected to the blower with Vee-Belts and Pulleys.

No vertical thrust shall be transmitted to the floor from the blower unit.

The complete blower unit shall be designed to operate without overload on any component at the specified speed and operating conditions.

(b) Accessories

The following accessories shall be incorporated in the system to maximise safety, reliability and minimise vibration and noise to have an extended life of the machine.

(i) Pressure Relief Valve
(ii) Pressure Gauge
(iii) Non Return Valve
(iv) Flexible Connection

1.16 Surge Protection

1.16.1 General

Each **pipe** has to be protected against water hammer. The Work will be carried out in accordance with the results of the Contractor's surge calculations.

The system for the Pumping Stations shall be carried out by a surge vessel with an associated compressor if necessary.

The Contractor shall submit a water hammer analysis and a calculation of the dimensions of the protection measures for all pipelines. These submissions are to be presented in a format, which the Engineer can check so as to give his approval.

Result of the calculation decide on the type of surge equipment:

- bypass pipe
- surge vessel with gas balloon
- or a combination

1.16.2 Hydraulic Calculation of Static State

Based on the design and the actual data, all states during normal operation of the plant shall be calculated. The result shall be presented as QH-diagram of all parallel working pump sets and as a graph of the internal pressure in the transmission pipe, depending on the distance to the pump set for the significant static states.

1.16.3 Hydraulic Calculation of Dynamic State

Based on the above-mentioned static calculation, the following situations shall be investigated by calculations:

- switching on and off of the pump sets during normal operation,
- switching off of all pump sets caused by electrical power failure while at maximum flow rate,
- closing of the transmission pipe while at maximum flow rate.

The design requirement is that the internal pressure of the pumping facilities and pipe shall not increase above the rated pressure of the equipment, and the pressure shall not drop to a value at which the flow cavitates following the formation of vapour under negative (vacuum) pressure conditions.

1.16.4 Result of Dynamic State

Firstly, the calculation shall optimise the proposed equipment of pump sets and transmission pipe by determination of:

- operating time of the valves at the discharge side of the pump set,
- characteristics of the non-return valve at the discharge side of the pump sets and at the reservoir inflow,
- moment of inertia of the pump sets,
- operating time of the valves in the transmission pipe; and
- optimising the method of control in such a way that additional measures, for example a surge tank, might prove unnecessary.

After completion of these activities a statement shall be submitted as to whether additional measures are necessary or not.

1.16.5 Presentation of the Result

The assumptions and the execution of the calculation must be reproducible. The results shall be summarized in a table and/or a graph with evaluation and recommendations.

1.16.6 Determination of Additional Measures of Water Hammer Protection

If the above-mentioned target cannot be realized by the measures described above, then additional measures shall be necessary.

The reproducible results of this calculation shall be:

- volume of surge vessel
- type of the surge vessel either water- air with compressor or the closed type with gas filled balloon
- all dimensions and characteristics of the additional measures;
- dimensions of surge pipe and characteristics of the non-return valve; and
- locations of the level switch at the surge tank for the switching of the alarm annunciation;

On completion, confirmation by a graph or a table that the surge control requirements can be met by the proposed measures shall be submitted.

1.16.7 Surge Vessel with Bladder

A horizontal, vertical, floor standing, cylindrical, steel welded vessel is to be designed with four feet, transport eyes, manhole, pressure gauge with three-way cock and water connection at the center of the bottom, gas at the center of the top and connections for the water level switches. All flanges are to be for PN 16

according to DIN 2533. With replaceable membrane DIN 4807 or balloon in correspondence with the portable water regulations.

The test pressure shall be 30 % higher than the maximum operating pressure.

The internal coating, applied after sandblasting, shall be of epoxy with a minimum thickness of 0.3 mm. The external coating shall be as for the pipes described under Type C", 4.11.3 below.

The surge vessel will be connected to the common discharge pipe by a welded steel pipe via butterfly valve and dismantling piece. In this way the loss of air shall be avoided.

Type

Surge vessel shall be of the gas pressured vertical, horizontal, bladder type suitable for open-air installation. Surge vessel dimensioning shall be determined by the vessel manufacturer using surge analysis computer software. Details of the surge analysis calculations, detailed drawings showing materials of construction shall be submitted to the Engineer.

Quality Assurance

The surge vessel manufacturer shall have a test certificate for total quality assurance of the manufacturing process from the relevant authority (BSL, ISO etc.,) for the manufacturing facility of the surge vessel.

Total Quality Assurance system shall comply with ISO BS 5750, ISO 9001 or 9002 series. BS EN ISO 9001 or 9002 series or an equivalent acceptable to the Engineer.

The certificates valid for current production (years 2009/2010) shall be produced with the offer.

Surge vessel to be supplied under this contract shall only be from the approved factory location.

Design Requirements

The vessel shall be designed to maintain the pipeline pressure between –0.6 bar to 16 bar in the raw water pumping main. The raw water is expected to contain 50 ppm of fine sand particles.

The surge vessel shall be designed for anchor bolting to a concrete foundation. The supports shall be designed to with stand all natural loading, any hydraulic and pneumatic thrusts resulting from surges.

For basic data required for surge analysis please refer data given under pump specifications.

Hydraulic Test

The surge vessel shall be hydrostatically tested at 1.5 times the maximum working pressure for not less then 60 minutes.

At no time during this test the vessel shown undue deflection or signs of weakness at any point, nor shall the external surfaces show seating through the welded joints or leaking through gaskets or other deflects.

The contractor shall furnish the Engineer with certified results of the tests.

Performance Test

The surge vessel shall be factory tested for its performance. The supplier shall submit the test results before shipment of the vessel. Test results should show how the pressure transients very with the time.

Vessel

The surge vessel shall be made of welded steel shells and dome ends according to BS 1501 Part 1 or equivalent. The volume of the tank shall not be less than 2.5 m3 and a corrosion allowance of not less than 1 mm shall be allowed. The vessel shall be provided with a manhole access and a drainage system.

The vessel shall be of vertical type and mounted on legs.

The vessel shall be provided with all pipe works and connections, tapping points for instrumentation, vents and drains.

The vessel shall be protected with a safety valve.

Bladder

The bladder shall be made out of thermoplastic polyurethane or butelene each approved for use with foodstuff and shall be easily replaceable. The bladder shall be perfectly watertight and airtight after the installation inside the vessel.

Gas is housed in the chambers between the bladder and the tank. In the hut connecting with the pipe, there shall be an anti-extrusion grid for the protection of the bladder.

Fittings and Instruments

The surge vessel shall be equipped with the following.

- Flange outlets
- Inspection hole
- Drainage plug
- Glass tube levels indictor and guard with isolating valves
- Pressure gauge with isolating valve
- Safety valve
- Air inflation plug
- Supporting legs
- Lifting lugs

Painting

The surge vessel shall be painted as indicated below.

– Internal coating – food quality, coat of primer
– External coating – coat of primer plus a coat of enamel finish.

The vessel is connected to the header with a gate valve. The connection flange size shall be the same size as the header.

The protection equipment shall be maintenance free, easy to monitor and reliable.

The pressure test of the surge vessel shall be 1.5 x of the maximum pressure.

1.17 Diesel Generator Sets

1.17.1 General

The Contractor shall furnish and install the diesel engine generator facility for emergency power source for the duration of normal power interruption, as hereinafter specified.

1.17.2 References

The following standards are referred to:

– IEC 34 Rotating electrical machines
– IEC 801 Radio frequency interference

1.17.3 Type Rating and Characteristics

(a) Diesel Engine

Type	:	4 cycle, radiator water cooled, direct fan drive vertical straight or vertical V-type multi-cylinder, direct injection, electrical
Rotating Speed	:	1500 rpm
Starting	:	24V DC long life Lead-Acid batteries including small charger equipped with the engine.
Noise	:	Not more than 95 dB at 1 m from exhaust outlet.
Rated Output	:	As shown on this single line diagram and schedule of the Special Specifications.

(b) Generator

Type	:	Brushless exciter, 4 pole, indoor use.
Rated frequency	:	50 Hz
Insulation	:	Class H or Class F
Rated Voltage	:	AC 400V/230V, 3 phase 4 wire.
Power Factor	:	0.8 lagging
Rotating speed	:	1500 rpm
Voltage regulation	:	Max. ± 3.0% under load from no load to 100% rated load.
Class of rating	:	Continuous full load operation.
Cooling	:	Self-cooling

Ambient temperature	:	35 deg. C
Frequency regulation load	:	Max. ± 3 Hz under load from no load to 100% rated
harmonic distortion than 3% for	:	AC waveform total Less than 5% total no load to full linear load, and less any single harmonic.
Over speed strength	:	120% of rated speed for one (1) minute under no-load.
Withstand voltage	:	Power frequency 1000 V + 2E (1500 V min.)

(c) Control Panel

Type engine,) metal	:	Self-stand on the common base (with generator and enclosed.
Equipment included	:	(i) Frequency meter (ii) AC Ammeter with selector SW (iii) AC Voltmeter with selector SW (iv) DC Voltmeter (v) Running time meter (hour meter: digital) (vi) Automatic Voltage Regulator (vii) Over current relay (51) (viii) Voltage relay (84) (ix) Under voltage relay (27) (x) Instrument transformers (xi) Control SW (Run / Stop) (xii) Changeover SW (Auto / Manual) (xiii) Tachometer (xiv) Lubrication oil pressure gauge (xv) Lubrication oil temperature gauge (xvi) Coolant temperature gauge (xvii) Emergency stop pushbutton SW (xviii) Battery and charger (xix) Molded case circuit breakers (xx) Indicator lamps – Control power failure – Under generating power supply (status) – Under commercial power supply (status) – Charging – Start fail – Oil pressure low – Cooling water high temperature – Over speed – Emergency stop – Over current – Aux. Equipment failure – Cooling water level low – Oil level low – Others, if required.

1.17.4 Auxiliary Equipment

The diesel generator facility shall be complete with fuel system, exhaust system and all essential and desirable auxiliaries for a complete installation whether specifically mentioned in this specification or not.

(a) Fuel System

The following equipment of the fuel system shall be specified hereinafter and such equipment shall be complete with all necessary apparatuses.

- Storage fuel tank (4 x 24 hours full load operation)
- Fuel service tank (8 hours full load operation)
- Fuel pump

The fuel service tank shall be provided of rolled steel for a welded structure, not less than 3.0 mm thick, reinforced where necessary, and shall include a steel angle stand with gusset plates, fixing bolts and all necessary accessories.

The fuel service tank shall be included with all interconnecting piping, valves, oil level gauge.

The hand type pump shall be furnished, and shall be hand operated, semi-rotary type pump.

(b) Exhaust System

The exhaust system shall be suitably lagged to reduce noise, and shall be installed completely with a bellows type flexible joint attached to the engine, exhaust piping, expansion joints, an exhaust silencer hanging rigidly from the ceiling, and exhaust to the air.

The acoustic noise level shall not exceed 95 dB (A) at a distance of 1.0 m from the outside of the generator room.

The exhaust silencer shall be the standard model of a manufacture regularly engaged in the manufacture of engine exhaust silencers, and shall be the multiple chamber type. All nuts and bolts used shall be stainless steel.

The exhaust silencer shall be covered with insulation of a non-combustible type and jacketed with a stainless steel jacket. The insulation shall be refractory asbestos, held in place with stainless steel banding and covered with a 0.4 mm thick stainless steel jacket, secured with screws and jacketing lapped a minimum of 75 mm thick. Fittings, flanges and valves shall be insulated with asbestos covering material cut to fit.

1.17.5 Tests

(a) Factory Tests

The diesel generator facility shall be completely assembled at the factory. The diesel generator facility shall be subject, unless otherwise noted, to the following tests by the Contractor:

Generator with Exciter and all Panels

- Verification of construction tests
- Mechanical operation tests
- Electrical operation tests
- Fifteen (15) seconds of 150% over current test (type test report may be acceptable)
- Two (2) minutes of 120% over speed test (type test report may be acceptable)
- Steady state voltage regulation test (type test report may be acceptable)
- Transient voltage dip test (type test report may be acceptable)
- Temperature rise tests (type test report may be acceptable)
- Noise tests (type test report may be acceptable)
- Vibration tests
- Protection devices tests
- Deviation factor of wave form (type test report may be acceptable)
- Excitation equipment tests
- Measurement for calculations of characteristics
- Insulation resistance test
- Power frequency withstand voltage tests
- Accessories and spare parts tests.

Diesel Engine with all Accessories Equipment

- Verification of construction tests
- Mechanical operation tests
- Electrical operation tests
- Starting characteristic tests
- Ten (10) minutes of no-load operation test
- Load operation tests (type test report may be acceptable)
- Thirty (30) minutes of 25% load test
- Thirty (30) minutes of 50% load test
- Thirty (30) minutes of 75% load test
- Two (2) hours of full load test
- Thirty (30) minutes of 125% load test
- One (1) minute of 110% speed test
- Governor performance test (Type test report may be acceptable)
- Temperature rise tests (Type test report may be acceptable)
- Noise tests (Type test report may be acceptable)
- Vibration tests
- Protection devices tests
- Auxiliary equipment test
- Accessories and spare parts tests.

(b) Field Tests

After installation, the following assembling performance tests shall be executed before energizing:

- Verification of construction tests
- Mechanical operation tests

- Electrical operation tests
- Ten (10) minutes of no-load operation test
- One (1) minute of 110% over speed test
- Noise and vibration tests
- Insulation resistance measuring
- High voltage test

1.18 Testing of Mechanical Plant

1.18.1 General

All completed pump sets, switchboards, control panels and valves shall be subject to testing and inspection before despatch from their place of manufacture, with all tests arranged to represent the working conditions -as closely as possible.

No item of equipment shall be delivered to site without inspection having been carried out or waived in writing by the Employer.

The Contractor shall submit, a programme of tests. As many tests as possible shall be arranged together in accordance with the overall programme of the Contract Works.

A minimum of 14 days notice in writing shall be given to the Employer prior to carrying out any tests.

Test personnel shall be fully conversant with the items to be tested.

The tests shall include the following

- Inspecting and Witness Testing of Pumpsets, Switchboards, Control Panels and Valves on Manufacturers' Premises
- Pre-installation Tests
- Site installation Tests
- Pre Start Up
- Initial Start Up
- Pre-commissioning trials
- Tests on Completion
- Tests after Completion

These tests shall be regarded as the minimum requirement and shall include the setting up and adjustment procedure in accordance with the manufacturer's instructions to ensure conformity with the specification stated by the manufacturer.

The tests shall demonstrate compliance with specified requirements and also the compatibility of interconnected equipments, the adequacy of their interconnections and the interchangeability of modular items.

The Contractor shall record the results of tests on the forms provided by the Employer with clear references to the equipment and items to which they may refer, so that the record can be used as the basis for maintenance tests during the working

lire of the equipment. These records shall be appended in the Works Operating and Maintenance manual.

Where specialised equipment is supplied the Contractor shall provide the associated test sheets which shall be submitted to the Employer for approval prior to the tests being carried out.

Pre-commissioning trials, Tests on Completion and Tests after Completion shall be carried out as specified in Employer's Requirements.

1.18.2 Spares

All spares shall be tested and available throughout all tests.

1.18.3 Test Equipment

The Contractor shall supply all equipment necessary to test the Contract Works. Equipment required for site testing shall include proprietary diagnostic, equipment and simulators. A list of test equipment shall be supplied by the Contractor prior to commencement of testing.

Where detailed in the Contract specific items of site testing equipment shall become the property of the Employer, and all such equipment shall be new.

1.18.4 Testing of Pumps

(a) Certification of Type Tests

The Contractor shall provide with his Tender, certified evidence, to the satisfaction of the Employer, that the required type tests have been performed successfully on identical equipment or equipment which is for all practical purposes similar and produced in the factory where the equipment offered is to be manufactured.

(b) Inspection and Testing of Pumpsets on the Contractor's or Manufacturer's Premises

Each pump of rated capacity 25 kW and higher shall be statically hydraulically tested at the works to a pressure at least 50% greater than the maximum working pressure which it will incur. During the test, the pump shall show no signs of leakage or failure of any components.

Each pump shall be tested with its own. motor supplied from its soft starter or variable speed controller in accordance with procedures described in ISO 3555 Class H tests or equivalent, BS 599 or equivalent and BS 4999 or equivalent at the manufacturer's premises to show the plant is capable of achieving the duty point values as detailed in the Contract. Site conditions shall be simulated as near as possible particularly the suction conditions.

Pump characteristic curves shall be produced for the following

1 Head/Quantity
2 Power Absorbed/Quantity
3 O' Efficiency/Quantity
4 NPSH Required/Quantity

The Cavitation tests detailed in ISO 3555 Class B Tests or equivalent shall form part of the tests.

Heads shall be in metre Quantities shall be in m3/hr. Power shall be in kW. NPSHR shall be in metres. Efficiencies shall be in percent.

(c) Site Installation Tests

Tests shall be carried out to ensure that pumps have been correctly levelled and aligned before such units are grouted or dowelled in position.

Before the coupling bolts are inserted, alignment checks shall be carried out to ensure that the coupling concentricity and angularity are within the limits recommended by the coupling manufacturer.

On completion of the installation head/quantity specific power consumption tests shall be carried out on each pump. Singly, in pairs, three pumpsets in parallel and four pumpsets in parallel as appropriate and the results plotted on suitable graph paper. The instruments to be used for these tests shall be those installed on site. The final results shall be included in the final operating and maintenance manual.

During the Tests on Completion all valves, pumps, blowers etc shall operate satisfactorily. Satisfactory operation shall mean operating at the guaranteed duty and efficiency without adversely overheating, overload, vibration or noise.

All of the works will be examined at the conclusion of the Tests on Completion to establish that all of the plant is reasonably free from damage and wear.

If any defect is detected during the tests on Completion or during the maintenance period the faulty equipment shall be rectified immediately by the Contractor at his expense. If the fault cannot be rectified the Contractor must replace the defective equipment which must also be proven to be free from defect.

(d) Pumpset Tests after Installation

The units shall be tested in accordance with the relevant British or ISO Standards, especially ISO 3555 or equivalent, BS 599 or equivalent and BS 4999 or equivalent and test certificates supplied as evidence of conformance with the Standards.

If any vibration is detected of the pumpsets during commissioning or during the maintenance period the fault shall immediately be rectified by the Contractor at his expense.

If the default cannot be rectified the Contractor must replace the defective pumpset with another new pumpset which must be proven to be vibration free.

Pumps shall be tested to verify that the duty and efficiency are in accordance with the manufacturer's supplied data. Duties and efficiencies are to be guaranteed as detailed within the specification schedules.

1.18.5 Pre-Installation Tests

All equipment shall be subjected to a pre-installation test.

All equipment shall be visually inspected before installation to ensure that no obvious damage has occurred during transit and storage. Where relevant, the ranges, duty, labelling etc shall also be checked.

1.18.6 Site Installation Tests

During erection of the plant the Employer will inspect the installation from time to time in the presence of the Contractor's Representative to establish conformity with the requirements of the specification.

During installation, tests and inspections shall be carried out to ensure that pipework systems are installed such that the pump flanges, pressure vessels, pipe flanges etc are relieved of all external loadings from the pipework. If requested by the Employer, this shall be demonstrated by testing with dial test indicators during connection of pipework flanges.

A visual inspection shall be carried out by the Employer or his Representative and the Contractor to ensure compliance with the Specification and in particular the following:-

a. All plant complies with the engineering standards.
b. Workmanship is acceptable.
c. Labelling is correct.

Any plant which is not in compliance shall be identified by the Contractor and he shall carry out the remedial action, prior to a re-inspection taking place.

1.18.7 Cleansing

On completion of erection and before any disinfection, internal surfaces of vessels, pipework, tanks and sumps etc shall be cleaned thoroughly in such a way as to remove all oil, grit and other deleterious matter.

1.18.8 Disinfection of Potable Water Plant

Disinfection of the completed sections of the works and in particular vessels, pipework, valves and pumps shall be carried out by the Contractor. After disinfection a bacteria check shall be carried out. The Employer may carry out tests coincidental with the Contractor. Disinfection to the satisfaction of the Employer shall be carried out before any water flows to supply (laboratory results usually take 24 hours).

1.18.9 Initial Start Up

When supply to the control panels has been energized testing shall continue in the following manner.

a. Each item of plant shall be tested to ensure correct rotation.

b. Each Manual and Actuated valve shall be tested under normal system conditions to ensure correct operation. This shall include the setting of torque and limit switches where appropriate.
c. Each instrumentation loop shall be tested to ensure correct operation.
d. Each item of plant shall be functionally tested to ensure "Manual Control". "Remote Control" and "Automatic Control" functions.

All the above tests shall be completed to the satisfaction of the Employer or his Representative prior to any Tests on Completion taking place.

1.19 Sludge Dewatering Equipment – Centrifuge

1.19.1 Centrifuge

This section covers the general technical requirements for the Dewatering/thickening Centrifuge.

(a) General

The centrifuges shall be horizontal decanter type units comprising an outer rotating bowl and an inner scroll conveyor which shall rotate in the same direction at a slightly different speed. The scroll shall be arranged to thicken/dewater sludge to the conical end of the bowl to discharge through ports in the bowl periphery. Centrate shall be discharged through ports at the other end of the bowl for gravity discharge into the centrate well/sump.

The centrifuge shall have a variable speed bowl drive and a variable speed scroll drive.

The centrifuge maximum capacity shall have minimum additional 20% margin of hydraulic and solids loading over peak design values.

The centrifuge shall be fitted with a fluid coupling/soft start frequency drive to ensure a steady increasing load during start-up. The torque of the scroll conveyor shall be continuously monitored by analogue control so that the optimum speed of the scroll conveyor, for a specific duty, can be maintained.

The centrifuge shall be supplied as a completely assembled unit on a skid mounted frame.

The centrifuge shall be supplied complete with accessory equipment. Accessory equipment shall include motor control, frequency converter, push button stations, sludge diversion mechanism, central grease lubrication system, vibration isolators and a torque control station. The hydraulic power pack shall be mounted on a separate base and shall be connected to the scroll drive by a flexible hose.

The centrifuge shall be installed in an acoustic enclosed building. Suitable lifting facilities shall be provided for maintenance of centrifuge

(b) Centrifuge Controls

All Centrifuge and other related equipment operational functions shall be arranged for full automatic operation and are governed by a PLC system to enable startup, shutdown, thickening/dewatering, sequence.

The Centrifuge shall be driven by a VSD. The Centrifuge bowl speed/scroll base speed shall be set in the PLC. Once the plant is operating it shall be capable of continuous unattended operation twenty-four (24) hours per day or as per set time duration. It shall be the Contractors responsibility to arrange the equipment in the best engineering manner to fulfill the full automatic operation.

The scroll drive shall be automatically adjustable during operation to suit the varying characteristics and flow rate of the feed sludge to ensure optimum operating conditions.

The scroll conveyor torque shall be continuously monitored and controlled by an analogue controller so that optimum relative speeds are maintained. Should the solids loading exceed the set limit of the scroll drive torque, the drive shall raise an alarm signal and temporarily stop the feed sludge and poly dosing pumps. Once the drive torque has returned to a safe level the feed sludge and poly dosing pumps shall start and feed the centrifuge. If the torque remains above the allowable torque for a set time a further alarm shall be initiated and the centrifuge shall shut down.

The centrifuge shall be provided with all necessary interlocks to sequence with sludge feed pumps and flushing system.

The centrifuge shall be provided with sludge diversion gate or other diversion mechanism to divert the wet sludge during initial starting period of operation of dewatering centrifuge.

If the scroll is driven by separate hydraulic power pack hydraulic drive control panel shall provide the following control signals to/from the main PLC system:

- Differential speed indication (4-20 mA signal of hydraulic flow rate to the Principal's PLC. This shall be multiplied by a constant factor in the PLC to give the differential speed.).
- High torque alarm. (Very High-pressure switch to stop the Centrifuge and the scroll drive.)
- Low oil level signal. (to stop the Centrifuge and the scroll drive)
- High Torque indication signal. (High-pressure switch to stop the Sludge feed pump.)
- High oil Temperature signal.(to stop the centrifuge),
- Signal to open and close cooling water.

(c) Centrifuge Bowl

The bowl shall be of the solid bowl decanter type and shall be manufactured from stainless steel and protected for abrasive resistant material. The feed end of the bowl shall be provided with circumferential discharge ports. To protect against abrasion, the ports shall be replaceable and manufactured from high wear resistant material. The discharge port for the thickened/dewatered sludge and centrate shall be designed to ensure free discharge and to avoid any build up of material.

It shall be the Contractors responsibility to arrange the equipment in the best engineering manner to fulfill the full automatic operation.

The complete assembly including drives motor and lubrication system shall be mounted and aligned on a sub frame. The frame shall be a stainless steel or galvanised steel frame or reinforced concrete base frame. The galvanised or concrete base frame shall be painted to prevent corrosion due to any sludge build up on the surfaces.

Heavy duty anti vibration mountings shall be located on the underside of the sub frame. The frame shall be a galvanised steel frame or reinforced concrete base frame. The centrifuge shall be fitted with a fluid coupling to ensure a steady variation of load during start up and operation.

The equipment shall be complete with all necessary items for efficient dewatering and thickening Centrifuge operation.

(d) Scroll Conveyor

The scroll conveyor shall be manufactured from material which is capable of resisting the wearing & corrosive effects of the sludge. The scroll flight tips shall be designed to have a minimum life of 15,000 hours, they shall be protected by either ceramic or tungsten carbide tiles or sprayed with tungsten carbide.

The scroll and bowl assembly shall be statically and dynamically balanced before and after assembly.

(e) Outer Casing

The outer casing shall be stainless steel and shall be designed to ensure segregation of cake and centrate into their respective discharge hoppers. The casing shall be of two sections connected by a flanged joint with the upper half easily removable for inspection and servicing of the rotating assembly. The outer casing shall have insulation under cover with acoustic material for noise reduction. Noise level shall be reduced to less than 80dB @ 1 meter from the under cover.

(f) Centrate Discharge Chute and Surge Sump

The centrifuge assembly shall be fitted with a centrate discharge chute which shall collect all centrate without splashing. The centrate chute shall feed to a separate surge sump/hopper. The surge sump or hopper shall take up any surge during shut down of the centrifuge.

(g) Solids Discharge Chute

The centrifuge assembly shall be fitted with dewatered/thickened sludge chute which shall direct all the dewatered /thickened sludge into the conveyor/hopper

The solids Discharge chute gate shall be manufactured from 316 stainless steel material.

The discharge outlet shall be sized to deliver dewatered/thickened sludge without spillage, to the receiving conveyor/hopper.

A flexible connection to the centrifuge discharge flange shall be provided. The centrifuge discharge connection shall not transmit any vibration or load from the centrifuge to the discharge chute to receiving chute.

The centrifuge centrate chute terminates with a 300mm flange connection. The discharge pipe flange size shall be of Table E with table D flange thickness.

(h) Maintenance Platform

The walkways around centrifuge to provide maintenance access shall be of minimum 1000 mm width around the centrifuge and shall form part of the supporting structure platform. The access platforms shall be designed in a manner to allow maintenance and operating personnel to easily access lubricating points, bearings, inspection bowl drive, adjustment of weir plates, removal of centrifuge cover, access to instruments, access to manual and control valves of the centrifuge.

The hydraulic power pack shall be mounted on a separate base and shall be connected to the scroll drive by a flexible hose.

(i) Feed Pipe

The feed shall be at least 75mm diameter and manufactured from stainless steel. It shall be the counter-current type and shall be provided with flexible connections.

(j) Assembly

The complete assembly including drive motor and lubrication system shall be mounted and aligned on a substantial galvanised subframe. Heavy duty anti vibration mountings are to be located on the underside of the subframe.

(k) Bearing Temperature Monitoring

Temperature sensor shall be fitted to the centrifuge motor bearings. They shall be connected to the control room to provide an alarm and trip function if the Temperature exceeds the maximum temperature limit.

(l) Vibration Monitoring

Vibration sensor shall be fitted to the centrifuge motor bearings. They shall be connected to the control room to provide an alarm and trip function if the vibration severity exceeds the maximum vibration limit.

To ensure the maximum integrity of the vibration alarm system, the Contractor shall be responsible for ensuring that the vibration monitor, cables, connectors etc, are acceptable to the Engineer.

(m) Lubrication System

A central grease lubrication system shall be provided mounted on the centrifuge base assembly. The system shall comprise a single stroke level operated grease pump mounted on a grease reservoir with level indicator and grease distributor to provide volumetrically metered greasing to main bearings, scroll bearings, gear box and other equipment. Lubrication system details and bearings served are to be given with the tender technical data.

(n) Testing of Centrifuge

The Contractor shall allow for the sampling and testing of a series of tests for dewatering performance. The Contractor shall conduct the performance over seven working days at the settings selected by the Contractor as per the supplier's manual.

The dewatering performance testing shall be carried out in two phases. Initial two days testing will be carried out at maximum capacity of centrifuge. The second phase of testing shall be carried out for five days at the design capacity.

During the testing of centrifuge the following parameters shall be monitored calculated and recorded:

- Bowl speed (rpm)
- Centrifugal force ('g)"
- Pool depth (mm)
- Differential speed (rpm)
- Scroll torque (Nm) (in the case of variable speed scroll drive)
- Hydraulic oil flow (Litre per minute) (in the case hydraulic power back)
- Hydraulic pressure (Bar) (in the case of hydraulic power pack)
- Sludge feed (m3/hr)
- Solids loading (kg/hr)
- Feed solids concentration in sludge feed (%)
- Solids concentration in dewatered/thickened sludge (%)
- Polymer used (kg/dry ton)
- Centrate solids concentration
- Solids recovery (%)

The test will consist of four samples per day.

Samples, which will establish the solids concentrations of feed sludge, dewatered sludge and centrate, shall be collected at the rate of 1 per every two hour for each centrifuge.

For Dewatering Centrifuge

The samples taken for each Centrifuge shall be tested for total solids concentration in the case of dewatered sludge cake, and suspended solids (S/S) concentration in

the case the centrate and sludge feed. The dry solids content in dewatered sludge shall be twenty (20) percent or better.

1.20 Sludge Dewatering Equipment – Filter Belt Press

1.20.1 Filter Belt Press

This section covers the general technical requirements for the Filter Belt Press dewatering equipment.

(a) Filter Belt Press Process Description

The sludge shall be fed into the Flocculator tank and flocculated by a mixer. Diluted Polyelectrolyte solution shall be dosed into this tank to aid floc formation. The flocculated sludge shall overflow from the Flocculator into the gravity drainage section of the belt press. A distribution device shall be provided at the feed point to the belt. A head box shall prevent the spillage of sludge at the gravity zone. The gravity drainage section shall drain the free water. The sludge shall be then squeezed between the belts to remove more water. When at constant belt tension the sludge shall undergo incremental increase in surface pressure as the belts wrap around each roll. Belt tension shall be automatically maintained and adjusted during operation by means of pneumatic tensioning system. Belt cleaning is accomplished by continuous wash water spray using high pressure treated water.

Dewatered sludge from the belt press shall be transferred by the out loading belt conveyor into a skip or trailer.

(b) Control of the Filter Belt Press System

All operational functions of the dewatering equipment shall be controlled by a PLC. The PLC shall be programmed to provide for either manual control or automatic control of the plant. The operator shall monitor and control the equipment via the PLC system.

The PLC shall be programmed to provide appropriate interlocks for sequential operation. The normal sludge dewatering operation shall be automatic start up and shut down sequence as programmed in the PLC. The belt speed and roller pressure shall be adjustable to suit the characteristic and the flow rate of the sludge for optimum performance. The mode of operation, speed control and flow adjustment of the dewatering plant, shall require manual adjustment to produce drier sludge with clear filtrate. The dewatering process may require operator attention for visual assessment of filtrate and dewatered sludge cake for fine tuning of the poly dosing rate, the belt press speed and roller pressure.

All the required instrumentation shall be provided for the safe and efficient operation of the belt press. Instruments shall detect drive failure and trip the sequence progressively without spilling sludge. The speed sensor of Flocculator mixer shall detect motion for control sequence. A spillage detector shall detect spillage from the header box. Automatic belt tracking and tensioning shall be provided to ensure correct belt tensioning and tracking of belt press belt. Belt tracking and tensioning is carried out by pneumatic cylinders in response to corresponding belt tracking switches. The belt misalignment detector shall be used

to detect belt misalignment failure to stop the belt press. The pressure switches shall detect the low pressure of the treated water for the wash water spray system.

Operator Adjustable Parameters

Operator entry of the following parameters shall be provided on the PLC system:

- Pre-set time for auto dewatering start/stop.
- Manual start of belt press.
- Manual stop of belt press.
- Sludge pumping rate.
- Polymer dosing rate.

(c) Design Requirement

The belt press shall dewater sludge to the required performance, which is twenty (20) percent dry solids on average, or better. The belt press shall be designed to operate unattended for up to eight (8) hours per day during normal working hours. However during normal working hours operator attendance will be provided.

(d) Description of Belt Filter Press Equipment

The belt filter press shall be designed to dewater sludge by means of two seamed belts arranged to perform conveying, draining, pressing and dewatering functions.

The belt press system shall be capable of continuous automatic operation.

The system shall meet the design criteria specified in the process requirements.

The belt press system shall consist of the following main components:

- Structural frame
- Rollers
- Belt washing system
- Automatic belt tracking and tensioning system
- Filtrate pans
- One set of belts

The belt filter press shall utilise three dewatering zones in a sequence to accomplish dewatering.

The first dewatering section shall allow gravity drainage of the free water. The filter belt in this section shall be supported by free turning rolls and fixed low abrasion bars in such a manner as to create surface tension to facilitate the gravity drainage

The second section shall provide a low pressure zone where the upper belt shall converge with the lower belt at a specified dewatering angle and generate a continuously increasing pressure. Close tolerance sealing strips on each side of the wedge zone shall be provided to contain the sludge flow in this area. The sealing strips shall be mounted in such a manner as to ensure that no rubbing between the seals and belts occurs. The belts shall be supported in this area by free turning rolls

mounted on adjustable stainless steel brackets. These brackets shall make it possible to alter the dewatering angle in the low pressure section to accommodate the change in sludge dewatering characteristics.

The high pressure section shall be of the S-roll configuration to provide the maximum possible cake dryness. The upper and lower belt shall converge with the sludge cake between them and wrap around at least five S-rolls. The S-rolls shall be of decreasing diameter in the running direction of the machine. At constant belt tension the sludge shall undergo an incremental increase in surface pressure as the belts wrap around each roll. Belt tension shall be automatically maintained and adjustable during operation by means of a pneumatic tensioning system. Facilities shall be provided to ensure correct belt tensioning and tracking irrespective of the cake thickness.

Belt washing showers shall be provided to wash the belts in the continuous manner using high pressure water. These showers shall be suitable for use with recycled effluent water. A 100mm nib wall shall be provided beneath the perimeter of the belt press to contain the filtrate.

(e) Belt Filter Press Frame

The structural main frame shall be constructed of square tubular steel to ensure long service life and easy cleaning.

The frame design shall allow easy access and visual contact with all internal components.

The main frame shall incorporate stainless steel filtrate collection pans and shall provide for separate collection of filtrate from the three dewatering sections. The frame shall also be provided with lifting eyes for hoisting the machine by crane, and with stainless steel holding down bolts which screw into painted mild steel mounting plates.

The frame shall be sandblasted and covered with four coat polyurethane paint system. This shall provide resistance to corrosion caused by chemical or pH extremes.

(f) Rolls

All rolls shall be of sturdy low deflection design. Breast (tensioning) rolls, drive rolls, and tracking rolls shall be rubber covered and have a minimum steel wall thickness of 12mm. S-rolls shall be covered with rubber, fibreglass, or high density polyamide.

Table rolls (gravity and wedge sections) shall be coated with a similar system or be type 304 stainless steel.

Table rolls shall have a minimum wall thickness of 10mm.

S-roll bearing housings shall be of the steel pillowblock type. All grease nipples shall be accessible from the outside of the machine.

(g) Feedboxes and Seals

The feed assembly shall distribute the sludge of the lower belt using a feed chute with skirts. Feed shall be contained in the gravity section by stainless steel box frame assembly with rubber gaskets.

This shall provide continuous retention of the sludge on the belt through to the wedge zone head box. The wedge zone head box shall be similarly constructed of stainless steel with rubber seals around its edges. Attached to the wedge zone head box shall be two parallel aluminium sealing wedges to control the flow of the sludge in the wedge section. Tolerances of the wedges and the supporting rollers in the wedge area shall be such that a wedge zone seal clearance of less than 0.5mm can be maintained accurately. The belt press shall be provided with spillage detector.

(h) Filter Belts

Each of the two filter belts shall be of a seamless design. The belts shall be woven from polyester monofilament wires and the splice shall be no thicker than the original belt. Belt dimensions shall be such that 50mm is allowed at each edge of the nominal belt width to provide for additional sealing. Belts shall be edge protected in order to minimise the possibility of damage due to accidental contact of the belt with the frame of the machine.

(i) Belt Tensions

Belt tension shall be maintained and controlled pneumatically and shall be adjusted when the Belt Press is running. Increasing belt tension shall result in an increase in dewatering pressure applied in the high pressure section. Pneumatically controlled air bellows shall provide an axial thrust to stainless steel shafts attached to the breast (belt tensioning) rolls. The shafts (2) for each breast roll shall be mounted on opposite sides of the machine in parallel fashion. These provisions shall guarantee parallel movement of the breast rolls. Additionally, the system shall ensure even surface pressure in the high pressure section and shall guarantee proper belt tracking during change in belt tensioning, and cake thickness. Separate air controls shall be provided for upper and lower belt as to allow the tension for each belt to be adjusted independently each other. Belt tension shall be infinitely variable and adjustable without shutdown of the machine. Pressure switch to detect low air pressure shall be provided on air supply line for pneumatic control system of the Belt Press.

(j) Belt Tracking

A pneumatically controlled design with a proportional control action shall be used for belt tracking. The upper and lower belts shall have a separate belt tracking systems. Tracking shall be accomplished by a rubber covered roll situated across the machine's width. The tracking roll shall be pivoted at one end and allow horizontal movement, activated by two air bellows or cylinder on a cross slide-track, at the opposite end. A stainless steel scanning finger shall monitor the lateral movement of the belt at all times and keep the tracking roll in the required position to ensure true running of the belt by signalling the bellows attached to the tracking roll. Electric limit switches for belt overtravel detection, as for belt tracking mechanism, shall be provided on the machine to shut down the belt drive and all auxiliary equipment in the event of tracking failure.

(k) Belt Cleaning

Belt cleaning shall be accomplished by water showers. One belt shower assembly shall be provided for each belt. The belt shower assembly shall consist of a stainless steel header pipe equipped with flat, recessed nozzles and shall incorporate a manually operated wire brush purging system. The belt shower operating assembly shall be housed in a stainless steel hood across the full width of the belt. Similarly, a matching stainless steel water collection trough shall be provided beneath the shower head with the belt passing between the two pieces. This housing shall be incorporated with rubber seals to eliminate spray and to separate the belt wash flow (separate drain connection) from the filtrate. Filtrate collection trough under each zone is connected by hose to main sump. The trough is made of stainless steel.

Treated water shall be used for belt cleaning. Low water pressure detection control shall be provided in the belt cleaning assembly.

(l) Doctor Blades

Two doctor blades shall be provided to remove sludge from the belt at the discharge end of the machine. Doctor blades shall be of laminated fibre reinforced plastic with dual edges (replaceable).

The doctor blade assembly shall be spring loaded and constructed of mild steel coated with epoxy resin.

Springs shall be of stainless steel and manually adjustable.

(m) Drive

The belt press shall be driven by a variable speed system. Final drive shall be via a heavy duty chain and sprocket system. The drive shall be controlled by frequency controller. Speed sensor shall be provided for motion detection of belt. Electrical shearpin shall be provided in the SCA to protect against mechanical overload of the drive.

(n) Flocculator

The feed shall be mixed with polymer in a separate mixer/Flocculator unit, then fed to the gravity zone on the belt press. Speed sensor shall be provided for motion detection of Flocculator. The mixer shall be fitted with a geared variable speed drive to ensure optimum mixing energy is applied. The feed tank shall be fiberglass or stainless steel mounted on an elevated structural member.

1.21 Sludge Dewatering Equipment – Filter Plate Press

1.21.1 Filter Plate Press

The Contractor may offer a Filter Plate Press as an alternative to a centrifuge or filter belt press for the sludge dewatering system. This alternative shall be fully described by the Contractor and shall meet the same general performance requirements as specified above for the centrifuge and filter belt press systems. However for Filter plate press systems the dewatered sludge shall contain at least thirty (30) percent dry solids on average, or better.